# Innovation Policy in a Knowledge-Based Economy

June 2000

A MERIT STUDY COMMISSIONED BY THE EUROPEAN COMMISSION

ENTERPRISE DIRECTORATE GENERAL

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# EXECUTIVE SUMMARY

This report is based upon a Commission supported innovation policy study entitled "Innovation Policy in a Knowledge-Based Economy". It is the result of a series of expert group meetings, co-ordinated by MERIT. The focus is on innovation theory and policy approaches in a knowledge-based economy, with particular emphasis on policies geared towards improving innovation in and technology diffusion among small and medium-sized enterprises (SMEs).

The process of European integration has resulted in significant, successful rationalisation of industry, removing duplication, and taking advantage of economies of scale that arose with the Single European Market. However, many policies have led firms to focus their attention on the single market, and the question arises as to whether a sort of cocooning has taken place — do European firms tend to be too inward looking? The new European challenge, thus is two-fold. One aspect is to open up the field of vision of European firms to view the entire world as their potential markets. The second is to take advantage of Europe. That is, having alleviated many of the previous weaknesses of Europe, policy should change focus to take advantage of European strengths such as economies arising from variety. Recalling that competition is the ultimate driver of innovation, this calls for more entrepreneurial dynamism, a greater mobility of knowledge and more innovative risk taking of European enterprises. Innovation policy for the knowledge economy should focus on these aspects.

## The System-Based Approach towards Innovation and the Importance of Knowledge

In this report the system-based approach to technical change and innovation is used as a conceptual framework to assess the increasing impact of knowledge on the European Innovation System. In the system-based model, technical change and innovation are understood as taking place within a dynamic innovation system. Innovation activities are seen to be wide-ranging, involving many different activities, and many different actors or institutions. Further, the links between the various actors, institutions and modes of innovation are multidirectional and interdependent. Learning plays a central role in this model, occurring in many places, and learning in one location (the Research & Development lab, the production line, the marketing department, consumer activities) can inform any other learning activity. This means that within the system-based approach, there is a central role for the diffusion of knowledge, and active links operating through the transmission of knowledge, among all parts of the system.

> The system-based approach to innovation emphasises learning and diffusion as central to the performance of the innovation system.

The Green Paper on Innovation (com 95, 688 final) was also based on this system approach: a broad perspective was taken on innovation and on the factors hampering or facilitating the generation and diffusion of new technologies. In the years following its publication, the recommended routes of action were translated into more concrete policy actions, which were laid out in the "First Action Plan for Innovation in Europe" (com 96, 589 final). The Action Plan rested on three pillars believed to hold the key to improving innovation in Europe: fostering a genuine innovation culture, creating a legal, regulatory and financial framework conducive to innovation, and gearing research more closely to innovation at both the national and Community levels.

Knowledge flows are the glue of the innovation system.

In the mid and late 1990s, the important place of knowledge in the modern economy became increasingly obvious. It is important enough to induce the claim that we have moved into a knowledge-based economy, in which the role and significance of knowledge for economic activities have fundamentally changed. At the outset of this report**,** we suggest a change in terminology from "knowledge-based economy" to "knowledge-driven economy", which moves us away from historical parochialism, since *all* economies are based on knowledge, while emphasising that current contributions of knowledge are very much to the dynamics of our economy. This knowledge drivenness is not restricted to a few glamorous industries, but applies to all European industries, high or low tech. We identify the three most important changes associated with knowledge as an economic driver in today's economy. They have to do with knowledge and the market place, technologies that interact directly and explicitly with knowledge, and the nature and structure of the transactions and interactions among "knowledge agents".

- **Knowledge is increasingly considered to be a commodity. It is packaged, bought and sold in ways and to extents never seen before**

- **Information and Communication Technologies (ICTs) lower the costs of various aspects of knowledge activities, such as knowledge gathering and diffusion**

- **The degree of connectivity among knowledge agents has increased dramatically**

## New Insights: The Essential Features of the New Knowledge-Driven Economy

Improved understanding of the nature of knowledge, and how it is both employed and created have changed our views regarding its use and its diffusion. Most of the innovation that has economic impact is recombination of existing knowledge into new products or processes. For recombination to work well as a process itself, agents must have rapid, easy, cheap access to a large amount and wide variety of knowledge. This indicates the importance of knowledge diffusion or distribution. But equally, it must be stressed that central to the effective diffusion of knowledge is its absorption by new agents. Tacit knowledge is central to the process of absorption. Tacit knowledge is stored in the brains of people or the routines of organisations, whereas codified knowledge is recorded in some form (in digital format or

The increasing importance of knowledge in economic activities has brought us into a knowledge-driven economy.

in a document like a scientific article, a manual or a patent application for instance). Emphasis on the importance of tacit, as well as specialised knowledge, or any form of human capital that takes time and expense to generate, implies that human mobility may be an important facet of the distribution power, and one that differentiates between successful and unsuccessful systems of innovation. More generally, this report also underlines the importance of humans as holders and carriers of that knowledge.

Knowledge mobility is the impetus for innovation.

The renewed interest in innovation clustering is also closely related to issues of diffusion, since it is difficulties in diffusion of certain types of knowledge (tacit knowledge, in particular) that give clustering its impetus.

Closer examination of the multiple sources of knowledge creation and the knowledge supporting production in high *and* low tech industries has revealed that the knowledge bases on which innovating firms rest their activities have become broader and more complex. This holds for all innovating firms, regardless of the R&D intensiveness of their industry. Hence, there is a need to increase the absorptive capacity of European firms, especially small and medium-sized firms. Further, the view of innovation as recombination of existing knowledge indicates that variety in diffusion of and access to knowledge must be seen as vital, and learning without research is an idea which must be treated as central to the innovation process. Finally, there is a growing number of knowledge- or science-based firms, partly associated with the increasing importance of high tech service sectors in Western economies. This has created issues in measurement of economic assets, and again has called attention to the importance of humans, this time as economic assets, in the knowledge-driven economy. The modern firm comes to resemble a professional football club — the assets of the organisation rest not in physical machines or buildings, but rather in the skills of its employees. One difference remains is that a firm can patent, and thereby assert property rights over, some of the knowledge or skills developed by its employees. Four main "knowledge" themes emerge.

Knowledge is created by using knowledge.

- **Diffusion of knowledge throughout the system of innovation is a key element of innovation and technical change**
- **Innovation without research deserves attention as an important source of technical advance**
- **The complexity of the knowledge base has increased, for all firms, in all industries and in all service sectors**
- **Humans are central as holders of (vital) knowledge assets**

## Consequences for Innovation Policy

An important question, and a central theme in this report is how innovation policy should respond to these developments.

Innovation as recombination and the growing number of science-based firms highlight the importance of absorptive capacity, individuals as knowledge agents, and the importance of knowledge distribution.

We define innovation policy as **a set of policy actions to raise the quantity and efficiency of** innovative activities, whereby "innovative activities" refers to the creation, adaptation and adoption of new or improved products, processes, or services. **Although these policy actions can be developed and implemented at various levels (local, regional, national, European) the focus in this report is specifically on policy actions that can be taken at the EU level.** This is a narrow **interpretation** of innovation policy and as such has two implications. First, it follows that policy should be guided by the question: "At the EU level, how can we define policy, which can not be implemented as efficiently at other levels?" This question focuses attention on the subsidiarity principle and its counterpart, the principle of additionality.

services. **Although these policy actions can be developed and implemented at various levels (local, regional, national, European) the focus in this report is specifically on policy actions that can be taken at the EU level.** This is a narrow **interpretation** of innovation policy and as such has two implications. First, it follows that policy should be guided by the question: "At the EU level, how can we define policy, which can not be implemented as efficiently at other levels?" This question focuses attention on the subsidiarity principle and its counterpart, the principle of additionality.

Innovation policy is circumscribed, but embedded in overall enterprise policy actions. It must be co-ordinated with other policies and policy goals at the EU level.

Secondly, this report discusses the scope of innovation policy and its relationship to other policy areas. The systems view of innovation forces one to take a very wide perspective on innovation. In doing so, however, there is the risk that the issue is enlarged so much that innovation policy becomes too pervasive. All policy actions would in the end have an effect on innovation and could therefore be considered as part of the innovation policy. A circumscribed policy sphere demands attention to the relationships between innovation policy and other policies, both in terms of policy actions, and in terms of policy goals. Different policy actions can contradict each other, and the pursuit of one goal may also interfere with the pursuit of others. A strong effort should therefore be made to detect the way innovation policies interact with other policies and other policy goals. These effects should be used in judging policy, both ex ante and ex post. Efforts at policy co-ordination can be extremely valuable here, watching out for possible negative (or positive) interactions, in order to initiate timely discussions with other policy-makers. Thus there is a need to re-focus, to define the limits of innovation policy and to create priorities for policy actions.

We propose to redefine the role of the EU and Community Action in the field of innovation and clearly to imbed this within overall enterprise policy actions. We can see immediately two backdrop policy approaches that will be useful:

- **Co-ordinate the innovation policies among Member States**

- **Harness a coherent strategy for innovation, by updating the analytical and empirical foundation of policy action, through studies and benchmarking activities that directly link innovation research to specific policy actions, such as the Trendchart project**

## Policy Priorities for the Knowledge-Driven Economy

The rise of the knowledge-driven economy has drawn attention to different aspects of the innovation system as important in its performance, as described above. These new pillars of success map to new policy priorities to improve enterprise performance in innovation, and to create the conditions under which enterprises can capitalise on the new situation. The diffusion or distribution properties of an innovation system are affected directly by the mobility and training of knowledge workers who hold tacit and specialised knowledge. Diffusion, particularly of codified knowledge, is further affected by the intellectual property rights system, and by the ability of firms to exploit the new information and communication technologies. The centrality of individuals as creators, holders and carriers of knowledge reflects mobility and training, but in addition raises issues having to do with financing innovation — how can the financial markets, whether venture capital or traditional equity markets, evaluate the assets of a firm when they are intensely embedded in its employees. Whether an enterprise can adapt to the increasing complexity of its knowledge base will be determined in part by the training of its employees, whether it is able to hire in the expertise it needs, and whether it can find and employ the knowledge it needs, that is, on the state of the intellectual property rights and information and communication technology (ICT) systems. Innovation without research is much more effective if the knowledge created outside "usual" knowledge-creation activities (the Research & Development laboratory for instance) is transmitted efficiently to other parts of the systems. Mobility and training, and exploiting the new ICTs hold the key here. The policy priorities mapped here are seen again in the results of the Community Innovation Survey regarding the experiences of enterprises, which have suffered set-backs in innovation projects.

- **Information and Communication Technology exploitation. Advantage should be taken by European firms and institutes to exploit the possibilities and opportunities that ICTs offer. These ICTs enable increased interconnectivity between knowledge agents through (virtual) networking**

- **Knowledge Mobility and Training. The importance of tacit and specialised knowledge calls for greater mobility of knowledge workers and investments in training and education**

- **Intellectual Property Rights** (patents, copyrights, design registration) **can be important instruments to codify and commodify knowledge and hence, the diffusion of knowledge. Their dissemination and use should be further stimulated, while keeping in mind the limitations of IPRs as a dissemination mechanism.**

- **Funding conditions (financial and fiscal) should be geared to more innovative risk taking and better rewards thereof**

It is the combination of these priorities, access to knowledge and finance that will enable and stimulate European firms to undertake innovative activities. It should expand their innovative potential, in particular that of SMEs, and ultimately ensure their competitiveness in the long run.

## Policy Directions

### General Policy Considerations

- Innovation is important in all industries, from high to low tech. Policy makers must not be seduced by the glamorous industries. When it comes to innovation policy all industries should be targeted.

- European heterogeneity or variety can be exploited through networking of firms and scientists, to create a vibrant learning culture in which many different ideas and approaches are available as inputs to firms' innovation and learning.

- Small and medium-sized enterprises need a variety of institutions, which take into account their heterogeneity, to assist in improving their ability to absorb new knowledge and technology.

### Information and Communication Technology Exploitation and Networking

- Invest in new technologies and infrastructure to increase European capacity to transmit knowledge that is not easily codified, but which can be transmitted electronically. This would permit the growth of European expertise in fields that require very specific inputs that are either too rare or too costly to be available extensively throughout Europe.

- Programmes to encourage networking of firms and centres of excellence within Europe should be expanded to include agents *outside* Europe who can provide Europeans with "knowledge-value-added". SME participation in alliances should be encouraged both internationally and with larger firms that typically have experience in this venture.

- Co-ordinate national telecom infrastructure investments to facilitate European networking to create knowledge sharing among firms through permitting them to undertake joint innovation projects at a distance. One goal is to create a truly European very high speed backbone.

### Intellectual Property Rights

- The European patent system needs to be harmonised, thereby reducing part of the economic costs of gaining a patent and increasing transparency for enterprises. Therefore, the European patent must continue to be developed.

- The intellectual property rights system must be used as a way to distribute information effectively, especially among small and medium-sized enterprises. This could be achieved by limiting patent width and increasing patent height in order to reduce the ability of patents to block competitors from using and further developing enabling technologies. In the same line, it may be worth increasing the level of the inventive step to prevent nuisance patents. In return for limiting patents, a better system for resolving patent infringement cases would be worthwhile. In particular, the system should be designed so that large firms do not have a distinct advantage over small firms. Any moves to extend patent protection to software must ensure that this does not have anti-competitive, and anti-distribution effects.

**Knowledge Mobility and Training**

- Mobility of knowledge among firms must be facilitated. This could be achieved by stimulating co-operation among firms in their knowledge activities, or by facilitating senior knowledge workers visiting, for a medium term period, other firms, universities, or research institutes. To this end the creation of a "European College" should be considered. Such an institution would provide experts with the financial and career infrastructure to move for extended periods of time without a disruption in their career paths and without disrupting their social security arrangements.

- Life-long-training programmes must be designed to reduce the polarising effect from the tendency to train even further already highly-skilled labour. Training programmes should be available for workers at all skill levels particularly in services, as human skills are a crucial input to innovation in that sector. European accreditation standards would permit cross-border mobility at more levels of the labour force.

**Funding Conditions (financial and fiscal)**

- The ability of banks and venture capital funds to tap European technological and entrepreneurial expertise regarding new and novel technologies must be improved by creating a European network of expertise, including technical (from the European research community), and entrepreneurial expertise, (from business angels for example) on which banks and other financing institutions can draw.

- Standards for reporting and documenting the value of intangible assets should be explored. A European standard is desirable to facilitate a European capital market and thus the EU can play a co-ordinating role.

- An innovation-friendly fiscal environment needs to be further developed. A review of taxation policies should be undertaken to evaluate their effects on innovation activities, and taxation should be designed considering their stimulating effects on innovation.

# INTRODUCTION

This report is based upon a commission supported innovation policy study entitled "Innovation Policy in a Knowledge-Based Economy". Its goal is to assess current EU innovation policies in light of the transition of society towards a knowledge-driven economy and to recommend further policy actions. These policy recommendations are specifically aimed at meeting the Community Added Value requirement, which states that policy actions should only be undertaken at the Community level when these can not be taken at the level of the various Member States.

For this purpose, MERIT (NL) has co-ordinated a series of expert meetings, held between July 1999 and February 2000. The expert team consisted of eight highly experienced innovation policy researchers from various EU countries and Norway[1]. In addition, two representatives of the Commission department in charge of innovation policy attended the meetings. This report will take, as much as possible, an enterprise perspective on the transition towards a knowledge-based economy. This means that we will try to assess what the implications of the knowledge-based economy for European firms are, and how and under what circumstances they can benefit from the transition towards this new economy. Hence, the emphasis is on policies geared towards improving innovation by, and technology diffusion among, small and medium-sized firms (SMEs) with the ultimate goal of maintaining and improving their competitiveness.

The report is divided into 4 chapters. This first chapter begins with a discussion of the two main themes of this report, namely innovation policy and the transition towards the knowledge-based economy. To understand where Europe stands now, in terms of innovation in the knowledge-based economy, and how the future of European innovation policy must evolve, we include a brief history of European integration. The chapter ends with four priorities, which should serve as the guideposts for the design and rationalisation of future innovation policy. In chapter 2, we discuss in more depth some of the recent academic insights concerning the role of knowledge and systems of innovation. We then draw attention to three phenomena, which have accompanied the rise of the knowledge-driven economy and which have very important economic consequences, both in themselves and through impacts on and interactions with innovation. We refer to globalisation, the continued growth of the service sector, and intellectual property rights (IPRs). The first section of chapter 3 deals with aspects related to the ongoing globalisation in the generation and exploitation of innovations. The second section of chapter 3, addresses various aspects of innovation in services. The focus is on differences between the service sector and the manufacturing sector with respect to innovation, the importance of information and communication technologies (ICTs) to innovation in the service sector, and the role of human skills in the process of innovation. Finally, the move towards a knowledge-driven society has an impact on the balance between knowledge diffusion and knowledge protection, which is the main rationale behind the patenting system. Firms have a variety of methods to appropriate the rents of their innovative activities, one of which is to create intellectual property rights. But the IPR system has been designed with a second objective, namely the diffusion of information, and the third part of chapter three calls for a re-emphasis on this second aspect of IPRs, which has recently been, and continues to be, undermined by policy measures. Chapter 4 concludes and presents innovation policy suggestions to address the needs of the new knowledge-driven economy.

[1] We also wish to acknowledge the valuable contributions of A. Arundel and R. Narula.

# CHAPTER I. INNOVATION POLICY AND THE KNOWLEDGE-BASED ECONOMY

## I.1 Innovation Policy and the Perspective Taken in this Report

To avoid any ambiguity as to what is meant by innovation policy in this report, a definition is in order. We define innovation policy as **a set of policy actions to raise the quantity and efficiency of** innovative activities, **whereby "innovative activities" refers to the creation, adaptation and adoption of new or improved products, processes, or services. At the level of the firm or the institution these activities are undertaken** to introduce new and improved products, processes or services to increase productivity, profits or market share, with the ultimate goal to increase their competitiveness in the long run. **Although these policy actions can be developed and implemented at various levels (local, regional, national, European) the focus in this report is specifically on policy actions that can be taken at the EU level.** We have deliberately adopted a narrow definition for two reasons. We adopt a systemic approach to innovation and innovation policy, as developed in the 1993 Maastricht Memorandum[2] and taken up in the Action Plan for Innovation in Europe.[3] This approach indicates that there are many aspects to innovation and that many things impinge, both positively and negatively, on the innovation performance of an economy. Thus there is a strong need to focus attention on particular policy areas, and so a need for a narrow definition of innovation policy. Secondly, the filters of subsidiarity, additionality and Community Value Added demand that policy conclusions be circumscribed to actions that add value at the European level, and cannot be undertaken by national or regional policy initiatives.

> Innovation policy: "a set of policy actions to raise the quantity and efficiency of innovative activities, whereby "innovative activities" refers to the creation, adaptation and adoption of new or improved products, processes or services".

## I.2 The Knowledge-Based Economy: What Does it Mean?

There are many who argue that we are moving towards a new "knowledge economy", in which the role and significance of knowledge for economic activities has fundamentally changed. In some cases it is argued that this change rests on advances in information technology, which are leading to a 'paradigm shift', in turn involving basic changes in the economic rules of the game, for both business and policymakers. Proponents of such views can be found in business, in policy-making, and in innovation analysis.

[2] Soete and Arundel (1993).

[3] The First Action Plan for Innovation in Europe, Supplement 3/97 to the Bulletin of the European Union, Office for Official Publications of the European Communities, Luxembourg, 1997.

But what does it mean to speak of the knowledge economy? At the outset, it must be said that there is no coherent definition, let alone theoretical concept, of this term: this is a widely-used metaphor, rather than a clear concept. For some, at the present time, it seems to mean that knowledge is in some sense qualitatively more important than ever before as an input. Peter Drucker, for example, suggests that 'Knowledge is now becoming the *one* factor of production, sidelining both capital and labour.'[4] For others, there is the idea that knowledge is more important as a product than it has been hitherto. Then there is the view that codified knowledge is more significant as a component of economically-relevant knowledge bases.[5] Finally, there are those who argue that information and communication technology (ICT) is central to this process, since it changes both physical constraints and costs in the collection and distribution of information and in our general ability to codify. If a general idea can be extracted from these disparate notions, it is that the dynamics of the economy are coming to rest less on investments in physical capital and more and more on learning or investments in knowledge creation.

In the new economy, the role and significance of knowledge for economic activities has fundamentally changed.

It is difficult both to distinguish among and to assess these ideas. For example, any assessment of the contemporary role of knowledge must recognise that all economic activity rests on knowledge, not only in our society but in all forms of human society. Palaeolithic society was by any standards "knowledge-based", and palaeontologists have demonstrated the existence of well-formed bodies of knowledge with respect to animal behaviour, pyrotechnology, materials, mining, symbolic communication and even medicine. Looking to the recent past, the industrial economy of the nineteenth century was intensively knowledge-based, and it might be that many claims made about the current knowledge economy could plausibly have been made a hundred years ago. It is certainly true that knowledge accumulates over time, and that it changes the quality and quantity of economic output. But does this obvious point mean we are entering some new form of society, which is qualitatively different in terms of the use of knowledge?[6]

In all of these discussions ICT takes a special place. Many point to the rapid decline in costs of transportation and in particular communication that have taken place in the last three decades. But we must note that costs of ICT have been falling for centuries. Advances in ship technology, the invention of the railroad, the automobile, the airplane, the telegraph, the wireless, all involve significant reductions in costs of information transmission. More generally, though, knowledge refers to understanding and competence. It is clearly true that current developments in ICT are responsible for major changes in our ability to handle data

[4] P. Drucker (1998, p.15).

[5] "Perhaps the single most salient characteristic of recent economic growth has been the secularly rising reliance on codified knowledge as a basis for the organisation and conduct of economic activities…"; Abramowitz and David (1996, p.35) "Codified knowledge" refers to knowledge that has been systematised, and recorded in a language, whether pre-existing or new, as codes that can be read, stored and/or transmitted.

[6] In discussions of research, innovation, and knowledge creation in general, we observe three categories: data are the factual result of experiment or observation activities; information is data having been organised, categorised or systematised such that it can be transmitted or used as an input to "knowledge activities"; knowledge comprises the skill or theoretical or practical understanding necessary to be able to comprehend, manipulate or use data and information in useful activities whether for creation or teaching of knowledge or any other activity.

and information, but these are not themselves knowledge, and ICT does not necessarily create knowledge or extend knowledge. It is an information resource; which is not to answer the question "How does it *become* a knowledge resource?"

The dynamics of the economy are coming to rest less on investments in physical capital and more and more on learning or investments in knowledge creation.

All of these features of the modern economy can be seen as continuations of long-standing gradual trends. If this is the case, what is new? First, rates of change seem to have increased in the last three decades, which implies a need for faster responses to them. Second, it may be that because there are so many simultaneous changes we now see a new constellation emerging rather than a simple gradual evolution of an existing one. Third, the extent to which knowledge lies at the heart of growth does seem to be of a different order of magnitude than has been the case historically (with periodic exceptions of course). Any economy which involves production, by implication involves the technology of production; technology is embodied knowledge, so any production economy (and it is difficult to conceive of an economy with no production), is knowledge-based. Thus we suggest a change in terminology from "knowledge-based" to "knowledge-driven", which moves us away from historical parochialism, while emphasising that current contributions of knowledge are very much to the dynamics of our economy.

## I.3 What Has Changed, so that We Can Now Claim to Live in a "Knowledge-Driven Economy"?

These perspectives prompt an important question, namely what *has* changed in the last years, so that we can now speak about a knowledge-driven economy? The following aspects are important in this respect.

### Knowledge is increasingly considered to be a commodity

In recent years knowledge is increasingly treated as a commodity. It is packaged, bought and sold in ways and to extents never seen before. This trend is manifest in various developments, and has several implications. If knowledge is a commodity or asset, then it can be priced and eventually sold as a private good on the market. An example is provided in a recent issue of the EC publication Innovation & Technology Transfer:[7] "Just 18 months after its simultaneous flotation on NASDAQ and the London Stock Exchange, UK-based ARM Holdings, whose business is based on licensing its intellectual property (IP), had seen a nine-fold increase in its market capitalisation, to € 4 billion. The company does not make a single chip itself, but licenses its designs to partners such as Intel, Texas Instruments, Philips and Nokia, and derives 67% of its revenue from fees and royalties." In line with this trend is the observation that, increasingly, small firms use patents (to demonstrate their in-house knowledge) as a bargaining chip in their attempts to acquire venture capital and in seeking alliances with other firms. Further, since the importance of knowledge has come to the fore so

[7] *Innovation & Technology Transfer*, Vol 1/00, January 2000, p. 12.

strongly, more and more attempts are made to value knowledge stocks and flows, both at the enterprise level and at the country level.

## ICTs lower the costs of various aspects of knowledge activities

Foray and Lundvall claim that "even if we should not take the ICT revolution as synonymous with the advent of the knowledge-based economy, both phenomena are strongly interrelated … the ICT system gives the knowledge-based economy a new and different technological base which radically changes the conditions for the production and distribution of knowledge as well as its coupling to the production system".[8] Moore's law describes the tremendous rate at which computer technologies have been advancing.[9] Taking advantage of the consequent micro-processor performance increases, demands investments in physical and other capital. Data from the OECD indicate that the rate at which these investments are being made is increasing: expenditures on ICT investments (telecom equipment, hardware and software) as a proportion of Gross Domestic Product (GDP) have increased by 16% in the period 1992-1997 in the OECD countries.[10]

The evolving ICT developments have affected many aspects of the knowledge production and distribution chain. The most dramatic change has been in the area of codification and the transmission of knowledge, the costs of which have fallen dramatically as a result of the ICT revolution. For instance, Esp@cenet, initiated by the European Patent Office, is an on-line technical library providing easy and free access to technical information. It holds, and permits searches on 150 million pages of text and scanned drawings. It has been well received as is demonstrated by the number of hits (web site visitors), which is around 15 million per month, one year after it was launched.[11] Consider the enormity of the task (and the time it would take) to provide 15 million searches of 150 million pages without the use of computers and database technologies of the current generation.

## The degree of connectivity among knowledge agents has increased dramatically.

As a result of ICT, but also the ongoing increase in mobility, the exchange of knowledge between various actors, whether at the level of individuals, institutes or societies has dramatically increased. This change is due in part to the reduction in mobility costs and in part due to an increase in benefits. Technologies in general have evolved to include a broader base of knowledge. Thus for an innovator, the benefits of venturing far afield, both geographically and technologically, have increased. Or equivalently, the costs of *not* doing so, if one's competitors are, have increased.

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[8] Foray and Lundvall (1996), p.14.

[9] Moore's law states that the density of transistors on an integrated circuit will double every 18 months. This has been very robust since first stated in 1965, but further, the micro-processor performance has also tended to progress at the same rate. This has created huge increases in our abilities to use the computer to process data, solve problems, and implement algorithms. The advances in raw power have been accompanied by advances in our ability to harness that power, through, for example, advances in algorithm design.

[10] OECD Science, Technology and Industry Scoreboard 1999

[11] Innovation & Technology Transfer, Vol. 1/00, January 2000, p.15.

Other aggregate data exist, which further support the idea that we are moving towards a knowledge-driven economy. The OECD Science, Technology and Industry Scoreboard 1999 mentions the following factors. First, knowledge-based industries and knowledge-based service sectors have shown an average growth, which is higher than the average growth in the overall GDP (this implies that the relative importance of these sectors has increased). Second, OECD countries increasingly devote resources to the production of knowledge, as witnessed by increasing expenditures on R&D, software and public and private spending on education and training. Third, the importance of human resources and the quality thereof, has increased, and is claimed to be the major factor behind invention and the diffusion of technology. Within the EU, the share of investments in intangibles and knowledge — public education, R&D and software — in GDP has grown at 2.9% over the decade 1985-1995. In this Europe lags the US slightly: the US growth rate over the same period was 3.1%. The magnitude of investments in intangibles and knowledge is now 40% that of fixed capital formation. One area of potential concern is that in the US, since 1994 R&D investment has grown rapidly, whereas in Europe it has been flat since 1990.

## I.4 Impact of the Knowledge-Driven Economy on Innovation

One of the central questions in this report is how the transition towards a knowledge-driven economy has affected or will affect the process of technological change, innovation and diffusion. An overarching concern is with the state of the European Innovation System, and one of the goals of innovation policy must be to strengthen this system.

### The notion of innovation without research has come to the fore

Our point of departure is the systems-based approach to technical change and innovation, which was developed in the Maastricht Memorandum on European innovation and technology diffusion policy.[12] One of the important insights of the systems model of innovation is that innovation and knowledge generation take place in many activities, many of them outside the formal R&D process. Both production (learning-by-doing) and consumption (learning-by-using) have been stressed. A successful innovation system will develop mechanisms to take advantage of this "learning without formal research". A case in point is the service sector, which continues to grow in importance in all industrialised economies. In this sector formal R&D plays a much less important role than it does in manufacturing. So this growth of services alone implies a growth in innovation without formal research.

### Within the system approach, diffusion of knowledge throughout the system plays a central role in determining overall performance

The attention paid to learning without formal research has further drawn attention to the idea that there must be pathways which bring this learning into the innovative process proper, and permit the knowledge generated by formal innovation activities to inform these other learning

[12] Soete and Arundel (1993).

activities. Communication between all facets of the innovation system, largely defined, drives the performance of the system as a whole. While the move towards a knowledge-driven society does not change dramatically our fundamental vision of technical change and diffusion as a systemic, interactive, and multi-directional process, it does change the various system linkages or system interactions both within and between systems. Reduced costs of connectivity imply that the system can be more densely connected. Any agent can now be connected to many more agents at the same cost. This changes the general diffusion properties of the system, increasing potential sources of and clients for knowledge.

There is a danger however that in stressing innovation without research, one would forget the important place basic research holds in many industries. Both direct and indirect outputs of basic research make important contributions to innovation systems. Besides new instrumentation and generic technologies, indirect outputs of basic research lead to productivity gains in applied research by firms. This is also acknowledged by private firms, as their share in university research funding has increased in recent years. Firms now supply 3% of government research and 6% of university research funding.[13] *Towards a European Research Area* discusses the situation with respect to research in Europe and policies that might improve it. It is important to realise that research and innovation can be tightly linked and a need for co-ordination between innovation and research policy initiatives follows from a systemic view of innovation. In addition, public research continues to play two important roles. It can be a countervailing force to the short term constraints felt by any private sector or private-sector funded activities; and it is often linked with (higher) education. In the latter role, public research can improve the quality of education and training of future knowledge workers, and this has proven to be an important driver of the "acquisition" capabilities of societies.

Returning to the issue of the ubiquity of innovative activity, we must acknowledge that policies other than innovation policies can have important influences on innovative activity, and innovation policies can no longer be developed in isolation from other policies. Hence, the systemic approach implies a must stronger need for policy co-ordination.

## Innovators face broader and more complex knowledge surroundings

Innovators today need a broader knowledge base than they have in the past. Innovations involving more than one academic discipline are now very common. The obvious case is information technology: many products embody IT now which only 20 years ago were purely mechanical. An electric razor, for instance, contains between 500 and 1000 lines of software code; similarly for toasters. An automobile contains many more. These are simply the more obvious examples, but they reflect the trend of an increasingly complex environment in which firms have to operate. Firms now face the task of integrating different types of knowledge — both at the level of knowledge, and at the level of personnel. This requires knowledge management at the level of the firm, in order to cope with changes and increased complexity in "knowledge surroundings".

But there is a role for (supra)national governments here as well; to improve the knowledge distribution power within the system. Firm management of knowledge, particularly in

[13] OECD Science, Technology and Industry Scoreboard 1999.

complex surroundings, can be affected by changes in those surroundings. Much knowledge exists, which could, in principle be tapped by firms trying to solve the problem of incorporating knowledge that is new to them, but there is the difficult problem of finding it, and when found, integrating it in a useful way. Efforts should be undertaken to pool knowledge and ensure its rapid diffusion. This calls for structuring, archiving and cataloguing of information and more efficient diffusion through knowledge brokerage services.

### Humans are important "holders" of knowledge.

By itself, this is not a new thing. Human beings have always been important "carriers" of knowledge, stored in their brains. What is new however, is the fact that it is now recognised that tacit knowledge (knowledge not recorded or transformed into information), which people carry with them, is of crucial importance to firms and society. In recent years, economists have come to recognise that even while our abilities to codify knowledge and transmit codified knowledge increase, and the costs of doing so fall (through the ICT revolution), tacit knowledge remains vital to the process of innovation. Some go so far as to argue that it is the lynch-pin of the innovative process. The subtle point is that to take advantage of these increased abilities to codify knowledge we need to advance our tacit knowledge rapidly to keep pace with the advances in technology. Further, there is a need, from the social point of view, to ensure effective diffusion of this tacit knowledge. In the short run, this means finding ways to permit holders of it to carry it from firm to firm. One model, largely followed in the US, is to have relatively rapid job turn-over. We do not advocate this, as it brings with it many "hidden" costs. Rather, a way to facilitate joint knowledge creation or learning projects; or ways to permit workers to sojourn in other locations are more reasonable as approaches to this issue. There is a sense in which for the foreseeable future, knowledge and innovation policy must pay explicit attention to the role of tacit knowledge. This means paying careful attention to humans as holders and carriers of economically valuable knowledge.

## I.5 Europe's Present Situation in Historical Context

The advent of the knowledge-driven economy has revealed particular weaknesses of the EU vis-à-vis the rest of the world, and in particular the United States (US). The US has, by several standard measures, almost double the use of IT than does Europe,[14] better (innovation and/or start-up) financing conditions and a more entrepreneurial climate and stronger innovation culture. Factors like these are extremely important since they determine the context in which innovative processes take place. A brief historic perspective is provided in this section to explore some of the roots of these problems.

[14] Data for 1997; the measures are IT stock/GDP; IT stock per capita; Number of business PCs per 100 white collar workers; number of PCs per capita; number of online Internet users. (EITO; 1998, 1999). A place where Europe has a lead over the US in both production and use is in mobile telephony.

## The process of European integration

One of the goals of the EU is to achieve an integrated Europe. Soete and Arundel conclude that, for instance "the focus of research policies developed by the European Commission, as in other fields, has primarily been directed towards programmes to overcome the fragmented, national structure of European industry and markets. One of the main purposes of these policies was to permit economies of scale."[15] Hence, the strive for integration has, until recently, very much focused on aspect like process innovations and cost reduction. Elements like capital-labour substitution, or achieving scale advantages have been the rationales behind this process. The players (the objects of policy) that policy makers had in mind until the late 1980s were mainly large enterprises and hence most framework programmes were specifically aimed at these firms. However, the knowledge-driven economy calls for more dynamism and risk taking with respect to (product) innovation. This calls to the foreground a much stronger emphasis on the role that SMEs can play in the knowledge-driven economy.

But there is also the question about the level of implementation of innovation policies. Over the years, the degree of overlap between regional, national and European public instances being involved in rather similar policy making has gradually increased. Over the late 70's and 80's one witnessed a shift away from European public support for big science areas considered of strategic importance such as nuclear energy research (EURATOM) and aeronautics. The scope of these policies had been in line with the early European integration aims: reap possible scale economies in production and large scale research investment and secure European autonomy. Organisations such as CERN, ESA, EMBL became show pieces of European co-operation successes in science. With time passing though and the large nuclear energy and fusion programmes not developing their long held economic promises and in addition the heavy economic restructuring processes in coal mining and steel taking their toll in terms of employment displacement and social upheaval, it became politically increasingly essential to develop a more positive image of European integration.

In came new forms of more technology-based, industrial support policy for new sunrise sectors, such as microelectronics, in the form of so-called "pre-competitive" research support. In their emphasis on competitiveness, such policies did overlap with national technology policies — with the subsidiarity principle more or less invented as belated legitimisation of existing flows of money and responsibilities between EU, national and in some member countries regional authorities — but by adding some specific European networking requirements, such support policies did seem to respond to a European need for more networking across different, relatively closed, research and business communities. Unfortunately, as such policies developed and started to eat up a growing part of the European budget, the high-tech industries and large European firms which benefited most from such European pre-competitive research support programmes appeared to be those sectors and firms which came to lose most in terms of world market share. Hence, despite a growing European research budget, Europe has been losing ground most in international competitiveness in high-tech sectors.

Not surprisingly, the 90s witnessed a significant shift in European policy making in the research area. This represented a shift in the nature of public support: away from supply oriented technology push towards more market-driven, demand pull policies, with greater

[15] Soete and Arundel (1993, p. 89).

acceptance of the crucial role of users —individuals, firms and enterprises — and the intrinsic recognition that technical success does not necessarily imply economic success.

## I.6 New Priorities for Innovation Policy in a Knowledge-Driven Economy

In 1995, the Green Paper on Innovation was issued, articulating the most important factors that were believed to affect (both positively and negatively) innovation in Europe.[16] The document further included recommendations for future policy to enhance the innovative potential of the EU and its Member States. These were presented as different "routes of action", ranging from the improvement of innovation financing and fiscal treatment of innovation, encouragement of innovation in enterprises (especially small and medium-sized enterprises), to foresight activities, stimulation of mobility of academics and students, and establishing better links between research and innovation. The underlying view of innovation and technology diffusion adopted in the Green Paper was, as the suggested remedies already indicate, of a systemic nature: a broad perspective was taken on innovation and on the factors hampering or facilitating the diffusion of new technologies. In the years following publication, the recommended routes of action were "translated" into more concrete policy actions, which were laid down in the "First Action plan for Innovation in Europe". The first action plan rests on three pillars, which hold the key to improved innovation performance in Europe:

- Fostering a genuine innovation culture
- Setting up a legal, regulatory and financial framework conducive to innovation
- Gearing research more closely to innovation at both the national and Community level.

Since the publication of the Action Plan, many actions have been undertaken to achieve these objectives. Some actions have been successful while others have produced more mixed results. One problem with the Action Plan for Innovation has been that it tried to be all-encompassing, and this has resulted in an unclear overall strategy. No fewer than 13 routes of action were defined, and this has led to the problem that there were no clear priorities among the suggested actions. In many cases a critical rethinking of the current and suggested new actions can substantially simplify and rationalise the number and type of actions, thereby reducing their overall number. It would decrease the level of fragmentation and increase the level of priority attached to the remaining actions.

Following from the discussions above, and developed in Chapter 2, four priorities seem to stand out and need to be (further) addressed.

- **ICT exploitation**. Advantage should be taken by European firms and institutes to exploit the possibilities and chances that ICTs offer. These ICTs enable increased inter-connectivity between knowledge agents through (virtual) networking.

[16] Green paper on Innovation COM (95) 688 final and Supplement 5/95 to the Bulletin of the European Union, Office for Official Publications of the European Communities, Luxembourg, 1996.

- **Intellectual Property Rights** (patents, copyrights, design registration) can be important instruments to codify and commodify knowledge and hence, the diffusion of knowledge. Their dissemination should be further stimulated.

- **Knowledge Mobility and Training.** The growing importance of tacit knowledge calls for greater mobility of knowledge and knowledge workers as well as training.

- **Funding conditions** (financial and fiscal) should be geared to more innovative risk taking and better rewards thereof.

## Three key phenomena

Three phenomena have accompanied the rise of the knowledge-driven economy and have very important economic consequences, both in themselves and through impacts on and interactions with innovation. We refer to globalisation, the continued rapid growth of the service sector, and intellectual property rights (IPRs). These are discussed more fully in chapter III.

Innovation in services tends to be stimulated by the use of knowledge embodied in capital goods, the use of a highly-qualified staff and a low degree of formalised knowledge generation. Investments in information and communication technologies often go hand in hand with new product and especially with process improvements.

The dissemination of new ideas, know-how and technical expertise respects neither the frontiers of individual states nor European frontiers. Inventions and innovations are transmitted from one part of the world to another with an unpredictable pace. While large firms realise and take advantage of this fact through international co-operation, smaller firms have difficulty co-operating with foreign, and especially, non-European partners. Administrative difficulties, and fears about whether there will be a market for the outcomes of international collaboration are given as reasons for this reticence.

Intellectual property rights (IPRs) such as patents, design registration and copyright have attracted growing policy interest in the past decade. While intellectual property rights exist to provide incentives for private agents to innovate, they are also, in principle, an important vehicle for information diffusion. It has been estimated that patent documents contain 80% of the world's accumulated technical knowledge.[17] Nonetheless, there is a strong tendency among firms, particularly among SMEs, *not* to use patents as a source of technical knowledge. Our approach to IPRs, which recently has been to strengthen the protection they provide, may be in need of re-consideration, in order to re-capture the second important aspect of them, namely information disclosure *to facilitate information distribution.*

[17] *Innovation & Technology Transfer*, Vol. 1/00, January 2000, p.15.

# I.7 Filters and Constraints

Having defined the priorities that should guide the rethinking of new policy actions in the field of innovation policy, we re-emphasise that innovation policy has a narrow definition. Recall that policy actions should be undertaken at the EU level. Two guiding principles, adopted by the Single European Act and the Maastricht Treaty are important: the subsidiarity principle; and the cohesion principle.

The subsidiarity principle states that whatever can be done at the local governmental level, should be done at the local governmental level (member states, regional, local). From this follows the principle of additionality, which should be guided by the question "At the level of the European Union, how can we define policy, which can not be reproduced at other levels?" If it can be reproduced, it should not be undertaken. This would focus attention automatically on the Community Added Value requirement. David *et al*. (1995) define four rationales for achieving additionality in the area of research and technology development programmes, namely "through promotion of economies of scale and scope, addressing of externalities, promotion of the development of the EU, or co-ordination." These rationales can be applied to EU policy making in the field of innovation policy. Finally, the principle or goal of social cohesion plays an important part in policy thinking. One goal is to make all the population of Europe full participants in the European project, and to aid in reducing regional disparities. As an example of how innovation policy interacts with cohesion, there are strong reasons to believe, today, that when innovative activities are geographically clustered they are more efficient.[18] Following this logic strictly, policy could inadvertently perhaps, create oases and deserts: regions of high innovation and knowledge surrounded by areas of low innovation and knowledge. Thus clustering policies, when seen in the light of the cohesion principle, must be meliorated with policies to soften the desert-oasis effects.

[18] See INLOCO (1999).

# CHAPTER II. RECENT CHANGES IN OUR UNDERSTANDING OF THE INNOVATION PROCESS AND THE ROLE OF KNOWLEDGE

Among economists who study innovation and technical change, the linear model, has been abandoned. Rather than seeing innovation as a uni-directional process involving basic research, applied research, development and marketing, with each function separated both in principle and in location, economists now use a network or web model of the innovation process. The knowledge generation inherent in innovation takes place in many more than just the R&D laboratory — it happens in addition for example in production, consumption, education and training — and the many different knowledge generation and use activities are seen as linked to each other in a dense network of connections between activities, institutions and agents. The general policy implications of this change are two. First, since knowledge generation, which lies at the heart of innovation, is of many types and takes place in many locations, the types of measures considered by policy makers must be broadened beyond the traditional support of R&D and provision of intellectual property rights. These two policies address only a small part of the entire innovation complex. Second, because of the strong links among the parts, innovation policy must take a systemic view. Policy administration cannot be done piecemeal (for example having a research policy independent of a development or diffusion policy), rather it must take a systemic approach. This view towards innovation policy is expressed in the Maastricht Memorandum of 1993, and can be seen in policy documents that have followed such as the Green Paper on Innovation and the Action Plan for Innovation.

Since the publication of the Maastricht Memorandum in 1993, further changes in our view of innovation have taken place. Responding in part to the technological changes discussed in the introduction, economists have both developed the systemic approach, and found new factors that had been largely overlooked and which feed into the innovation process in ways as yet un-noticed.

## II.1 National Innovation Systems and the Centrality of Knowledge

Since the early 1990s the concept of a national system of innovation has been introduced, developed and used for policy analysis of the innovative performance of an economy. Initial insights had to do with the importance of different types of institutions in the nation innovation system, and that in particular innovative activities linked a firm to many other types of agents: universities; R&D institutes; consultants; legal institutions; marketing agencies; suppliers; consumers and so on. This development was intimately linked to the development of the network model of innovation, and the view put forth in the 1993 Maastricht Memorandum that innovation is a systemic notion and must be treated, both analytically and from the policy point of view, as such. Indeed following in part from the Maastricht Memorandum, the systems concept has been developed since the early 1990s, and through the exploration of the glue that holds the system together, more and more emphasis has been put on the nature of the links between the different "institutions". With regard to innovation, these links operate essentially through knowledge flows. Researchers now emphasise the centrality of knowledge in the innovative process, and in the innovation performance of an economy. Research on the nature of knowledge has followed. But any piece of knowledge can increase in social value if more and more people have access to and use of it. A widely diffused minor innovation will have a much bigger impact than a dramatic knowledge advance that is kept secret. This implies an important place for distribution or diffusion in our understanding of the workings of an innovation system.[19]

A widely diffused minor innovation will have a much bigger impact than a dramatic knowledge advance that is kept secret.

## II.2 Developments in the Economics of Knowledge

It is now several decades since the public good aspect of knowledge was brought to the fore.[20] Because knowledge is non-rivalrous in use, and because it is costly to retain exclusive use of a piece of knowledge, the private value to a creator of a piece of knowledge is less than the social value of that knowledge. Thus, traditional knowledge policies have involved public funding of basic research, and the creation of the patent system. The first compensates for the public good aspect of knowledge, funding its creation out of public revenue. The second reduces the public good aspect, by creating transferable property rights to the creators of it. This policy approach rests on the view that knowledge is assimilable to information. Information is codified, completely recorded in some way, and is, thus, easily transferable among agents, even over large geographical distances. It is this ease of transferability (and thereby ease of "theft") that makes it difficult to appropriate the returns to knowledge generation and thus eviscerates private incentives.

Thomas Jefferson remarked that the same knowledge can be jointly used by many individuals at once: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me..."

### II.2.1 On the Nature of "Knowledge"

In recent years however, attention has been drawn to the complex nature of knowledge itself. Grouped under the generic term "knowledge" we find data, information, codified knowledge and tacit knowledge. Data, information, and some codified knowledge are easily transmitted. This is not the case for tacit knowledge however. Tacit knowledge is not recorded in any way, and resides entirely within individuals or organisations.[21] More and more frequently one

[19] See David and Foray (1995) for a seminal discussion of the "distribution power" of an innovation system.
[20] Kenneth Arrow (1962).
[21] In this context the word "tacit" rarely is explicitly defined. Polanyi (1958) introduced the term into modern circulation by referring to a component of human knowledge distinct from but complementary to knowledge explicit in conscious cognitive processes. Economists have a more general notion of the term, namely knowledge that is not codified, or often even more generally as knowledge that is not being articulated in standard practice. Much knowledge is transcribed into a language, onto a storable, transportable medium. It is thus codified — by the use of some code (a language) the knowledge is turned into messages. Tacit knowledge, by contrast, has not undergone this transformation. A standard example of tacit knowledge is the knowledge of how to ride a bicycle.

reads of a newer understanding of science and technology as being pursuits inextricably involved with tacit knowledge. Use of any piece of information intimately involves significant amounts of tacit knowledge. To read a scientific paper, for example, one must understand the language (including the jargon) in which it is written, understand the technical tools employed, and understand the model well enough to be aware of the hidden assumptions or premises employed. Often, however, even being able to read the paper is not enough.

While codified knowledge or information is easily transferred among agents in the economy, tacit knowledge is not: "Tacit knowledge can take many forms, but it cannot be written down. It is unique to an organisation — and therefore cannot be copied...The benefits of such tacit knowledge arise only through a culture of trust and knowledge-sharing**...".**[22] The presence and importance of tacit knowledge then, creates "sticky data".[23] Knowledge does not travel freely due to the importance of the tacit knowledge residing only in the heads of the scientists and engineers engaged in its production.

**The Importance of Tacit Knowledge**

Collins describes the case of the TEA laser — after the laser was built and the papers describing its construction were published, no laboratory was able to reproduce the result without first talking (face-to-face) with one of the original team. Important knowledge was not conveyed (apparently it was not deliberately hidden since the original team members were willing to talk to other scientists about how to do it) by the written account.

Playing a role similar to tacit knowledge is specialised knowledge. To read blueprints for a jet engine, one must know some advanced fluid-flow science (among other things). This knowledge is codified in many textbooks, but may be unknown to a potential user. To make use of these blueprints, one must acquire a significant amount of complementary, specialised knowledge. This again makes at least some knowledge sticky. Any economy with a shortage of agents knowledgeable in fluid-flow science will be unable to use the codified knowledge presented in the blueprints. The knowledge capital of an economy's scientists and engineers will determine which pieces of knowledge (codified or not) will be usable for it.

The importance of tacit knowledge, and specialised complementary knowledge reduces the mobility of knowledge in general. Both are key elements, which are embedded in humans and a shortage of them can reduce the diffusion power of an innovation system.

### II.2.2 Geographic Clustering in Knowledge Generation

The importance of non-mobile knowledge in science and innovation leads directly to the issue of geographical clustering in knowledge generation. This is an idea that has been present in

[22] Kay (1999, p. 13).
[23] Von Hippel (1987).

economics since Alfred Marshall first raised it in 1921, but has recently reappeared as the dynamics of technology have received growing attention.[24] This may seem paradoxical in the face of rapid growth in speed, availability and extent of the new information and communication technologies (the much-touted "death of distance"), but empirical research shows that clustering is still very important both in manufacturing and, and more especially, in innovation.[25] More sociological research indicates why this is so. First, while the new ICTs have facilitated the diffusion of codified knowledge, they have not yet done so for tacit knowledge; tacit knowledge must simply be communicated face-to-face. Some form of direct interaction is necessary.[26]

While the new ICTs have facilitated the diffusion of codified knowledge, they are only beginning to do so for tacit knowledge; tacit knowledge must simply be communicated face-to-face. Some form of direct interaction is necessary.

Second, in highly innovative industries or sectors, markets do not always work well to provide inputs and investments needed to create "next generation" technologies — when change is too rapid, markets cannot predict future needs. What serves this purpose instead is a common vision shared among firms and individuals in the industry.[27] This sort of common vision can only be created by frequent, often informal, contacts among these agents. For many reasons, some having to do with the nature of the knowledge being discussed, and some with the trust needed to share this kind of knowledge, initial exchanges about nascent technologies and enterprises intended to exploit them tend to require frequent face-to-face contacts.

Third, when a large number of innovators is geographically clustered, an innovation culture arises naturally. Innovation is the reason for being there, and non-innovators will quickly find that they are not full participants in economic or social aspects of the region. The agglomeration of innovators in this sense feeds on itself — it creates an innovation culture just through the presence of many like-minded individuals. This both attracts others and is self-reinforcing in that an innovation culture feeds innovation, which in turn encourages activities that strengthen the culture.

In response to the arguments about the benefits of agglomeration of innovation, many western European governments have constructed elaborate systems of region-specific development aid and assistance, policies that have been perpetuated in the EU's administration of its Structural Funds.[28] The governors of American states, and mayors of American cities, equally, have been among the star adepts in the quest for regional employment-creation through "foreign" direct investment lured by tax rebates, local infrastructure subsidies, and labour force training programs — all paid for from public funds. More recently, they have been promoting the policies aimed at engendering regional revitalisation through the formation of clusters of high-tech firms located in and around research parks situated in the environs of universities.

[24] See for example the special issue of *Economics of Innovation and New Technology*, vol 8(1-2), 1999.
[25] See Swann, Prevezer and Stout (1999) for a study of clustering in biotechnology and computing.
[26] The same conclusion follows from the less extreme statement that the marginal costs of knowledge transmission rise very rapidly with "distance" from the context in which the knowledge was generated (Pavitt, 1987).
[27] See INLOCO (1999) for a discussion of this point.
[28] See, for example Martin, (1993); or Collier, (1994).

They are joined in such endeavours by others throughout the developed nations, including the French civil servants who directed the creation of the "Technopolis" at Sophia-Antipolis in the hills above Nice, and their Italian counterparts who did the same on the outskirts of Bari in Apuglia.

Clustering can raise the efficiency of innovation, particularly in industries built on new, fast moving technologies. But clustering, if pursued without caution, can create a relatively small number of oases in an innovation desert. The process of clustering by definition draws firms and individuals engaged in innovation to central locations. This can cause problems for the locations from which they have been drawn by creating human capital deficits. Thus a search for efficiency in innovation through geographic clustering can have negative effects on social cohesion.

### II.2.3 Newer Models of the Diffusion Process

Innovations, while valuable immediately to their creators, have a real economic impact only when they are widely diffused. This is an old insight, and has been extensively studied theoretically and empirically. Traditional models of diffusion tend to be a variant of epidemic models. Crudely put: an agent adopts an innovation as soon as he learns about it. He learns about it from having contact with an agent who has already adopted it. From this, one can deduce innovation rates based on a variety of parameters. Notice, though, that in this formulation location of agents plays no role. Any agent is equally likely to contact any other. Recently, location has been understood as important, and this has led to a new type of diffusion model, based on ideas of percolation.[29] In these models agents do have locations and they are (in the simple models) fixed, and agents can only receive information from those with whom they have direct connections. The second change in these models is that receiving information about an innovation is not enough; one must be able to absorb and integrate that information before it can be useful. This observation can be linked to the literature on absorptive capacity, and has taken an important position in the study of innovation.[30] In these models the probability that there is an adoption of the innovation this period depends on the probability that the information is transmitted to an uninfected agent and the probability that that agent can usefully absorb it. Two important aspects of the system have been highlighted: the degree to which agents are connected (how effective is the communication network), and the degree to which agents are able to absorb information. Analytical work on these models emphasises the importance of the latter.

The importance of absorptive capacity implies a second role for R&D. R&D is no longer thought to be aimed solely at the production of innovations, it has as well the goal of keeping the human capital of a firm "up to date" so that the firm is able to observe, evaluate and integrate new knowledge that is developed elsewhere. A successful technology strategy can be to "come second". That is, not necessarily to be an innovator, but to be a rapid imitator. But to pursue this strategy one must have very high absorptive capacity so that the reverse engineering and production of one's own version happens rapidly and effectively. Again, at the firm level, this capacity lies in the ability of employees to respond quickly to a wide variety of what will be largely external events. Employees must hold the right sorts of

[29] See David and Foray (1995).

[30] On absorptive capacity see for example Cohen and Levinthal (1989).

knowledge; or, if they do not, the firm must be able to tap that knowledge from outside itself. It must either be able to hire the expertise it needs, or to generate it by first finding it, and then learning and absorbing it.

> Receiving information about an innovation is not enough; one must be able to absorb and integrate that information before it can be useful. Keeping the human capital of a firm "up to date" so that the firm is able to observe, evaluate and integrate new knowledge that is developed elsewhere is necessary.

Arguments about the ability to use (or at least respond to) new, externally generated knowledge apply at all levels of aggregation. What is true for firms is also true for regions, nations and Europe. Moving away from firms the issue shifts from acquiring through hiring, to generating through research and teaching. From a public perspective, education and training take a central place. There must exist a good education system *that is broader than the industry structure of the innovating industries.* That is, quite naturally there will tend to be a coherence between industry structure and training at the university level. This provides the human capital needed for today's industry. If the education system specialises too heavily in these fields, it will diminish absorptive capacity in the sense that its graduates will have difficulty absorbing knowledge from outside these domains, which is crucial in today's innovation climate. The broadening of knowledge bases and the need to be flexible at the firm level implies a need for broadly educated and skilled personnel simply to remain competitive through innovation.[31] More generally, and more dramatically, major industry shifts at the macro level are made extremely difficult if the human capital of a region is too specialised.[32] The response here demands a general and diverse knowledge base at the European level, which will stem in the first instance from education systems that are broadly based and forward looking. It must be understood, however, that this implies a willingness to suffer a certain amount of brain drain.

> When knowledge bases are broadening, success demands being able to access outside information, knowledge and expertise.

### II.2.4 Sources of Knowledge and Innovation

Innovation cannot be understood if it is treated as learning that takes place in a vacuum. Innovation (and learning more generally) occurs on the basis of existing knowledge which has accumulated over time and which forms a point of departure. This knowledge is both private, built up by the firm in its experiences and existing in its competences, and public, created and transmitted through education and training, public research, published findings and so on, and held in a very diffused way throughout the economy or society. This knowledge may not in the past have been of central relevance to the innovating firm. Innovation is learning as problem-solving with respect to the existing (relevant) knowledge base.

[31] In this regard, studies of job mobility among engineers show that the more broadly based his education, the more easily an engineer moves from one job or project to another. This type of flexibility at this level is what underpins flexibility at firm, region and continental levels.

[32] Witness the current situation in Wallonia, Wales and the Ruhr valley, all of which face the enormous task of moving out of heavy, coal-based industry into modern growth industries or sectors.

The knowledge of a particular firm tends to be highly localised, and specific to the firm's product characteristics. A firm understands its product line and the knowledge and technology that relate to it. This knowledge is very specific but is not only technical; it is also social, concerning the way in which technical processes can be integrated with skills, production routines, use of equipment, explicit or implicit training, management systems and so on. Much of this knowledge base may be informal and uncodified, taking the form of skills specific to individuals or to groups of co-operating individuals. The tacit and localised character of firm-level knowledge means that while individual firms may be highly competent in their areas, this competence has definite limits. This implies first that they may run into difficulties when innovation takes them outside their specific area of expertise, and second that the ability to carry out search processes relevant to these problems will be circumscribed. Successful innovation in this situation demands being able to access outside information, knowledge and expertise.

There are also knowledge bases at the level of industry or product-field. At this level, modern innovation analysis emphasises the fact that members of an industry often share scientific and technological parameters; there are shared intellectual understandings concerning technical functions, performance characteristics, use of materials and so on. This has been referred to as the "generic" level of a technology: generalisations about how things work, widely applicable problem solving heuristics and the like. "Generic knowledge tends to be codified in applied scientific fields like electrical engineering, or materials science, or pharmacology, which are "about" technology."[33] Generic knowledge bases are highly structured and tend to evolve along structured trajectories.[34] This part of the industrial knowledge base is public in the sense that it is accessible knowledge in principle available to all firms and is developed, maintained and disseminated by a variety of institutions. The combination of knowledge and institutional base has been defined as the "technology infrastructure".[35] Finally, there are widely applicable knowledge bases, of

**Knowledge areas supporting the (low-tech) food industry:**

additives; analytical chemistry; bacteriology; behavioural sciences; bio-chemistry; biological preservation (e.g. fermentation); bio-technology; chemistry; cooling/freezing technology; design; disposal technology and environmental issues; economics; filtering-, centrifugal-, washing technology; gastronomy; general transport technology; heating and refrigerating technology; hermetics and modified atmosphere packing; IT and informatics; logistics; marketing; materials technology; micro-biology; pasteurisation and homogenisation; process lines (engineering, informatics); sensoric analysis and evaluation; sociology; spectroscopy; steaming (thermic treatment); sterilisation; testing/measurement technology; texture; vacuum technology.

33 Nelson (1987, pp. 75-76).
34 Dosi (1982).
35 Tassey (1991, p. 347).

which the most important technically is the general scientific knowledge base. This is highly differentiated internally, and of widely varying relevance for industrial production and innovation. Certainly some fields such as molecular biology, solid state physics, genetics or inorganic chemistry have close connections with major industrial sectors. We must emphasise, though, that organised science does not evolve according to some self-contained, internal dynamic, rather it is in fact shaped by industry, policy and funding decisions which have economic, industrial or military objectives.

When knowledge is brought to the fore, and the issue of knowledge bases is raised, an important empirical generalisation can be made. For virtually any industry that is innovating, knowledge bases are broad in terms both of the "disciplines" involved, and in the types of institutions that provide outside support of those knowledge bases. One of the features of the modern knowledge economy is that the breadth of the knowledge base on which virtually any industry sits has increased. The complexity of the underlying knowledge bases has grown substantially. Keith Smith (1999) has analysed the knowledge bases of the Norwegian offshore industry and food processing industry. According to an OECD classification, developed in the mid-1980s, which distinguished between industries in terms of R&D intensities, these are medium-technology, and low-technology industries respectively. The knowledge base(s) appropriate to these industries display great technical depth and variety. The list of institutions providing support and development of these different knowledge bases is similarly long and diverse. Thus a low-R&D industry may well be a major user of knowledge generated elsewhere. [36]

> Almost all innovation consists of a recombination of existing ideas or knowledge, put together in a novel way to create a new product or process.

### II.2.4.1 Innovation as Recombination

This discussion of knowledge bases leads naturally to another idea that has received attention in recent years. The striking variety within the knowledge base of any industry indicates that a wide variety of expertise typically goes into innovative activity. Further, almost all innovation consists of a recombination of existing ideas or knowledge, put together in a novel way to create a new product or process. Economic analyses of innovation no longer treat it simply as a special case of research and development. While the history of technology contains examples of independent inventors creating entirely new products or processes, which after decades of diffusion have great economic significance, the vast majority of innovative effort is of an entirely different nature. It tends to be a search among known information, or a search strongly guided by existing knowledge for incremental changes to products and processes currently in use. A general trend observed is that within any product class, the knowledge base underlying production or innovation has broadened. That is, a wider variety of underlying knowledge is present in a typical product. The most obvious instance is the inclusion of computer electronics (and thus software) in everything from electric razors and bread toasters to locomotives and machine tools. Makers of any of these

[36] As Smith argues, one of the further shortcomings of the OECD classification is that it measures only one component of knowledge-creating activities, namely intramural R&D.

products (and many others) now must have internal expertise in electronics. But this is only the most obvious example, substitution of plastics, and now advanced composite materials for other materials demands new skills and knowledge; increased safety standards require changes in instrumentation and testing abilities. In virtually any innovative industry, firms are looking outside their "traditional" knowledge bases to find new ways to improve products and processes.

In virtually any innovative industry, firms are looking outside their "traditional" knowledge bases to find new ways to improve products and processes. Thus if knowledge is not distributed throughout the economy, it cannot contribute to innovation in locations other than where it was generated.

When innovation is seen as recombination, a crucial determinant of the success of an innovation system is the quality, variety and availability of knowledge to recombine. The more, and more varied, the knowledge at the fingertips of a would-be innovator, the greater his scope for (technically and economically) successful innovation. Two observations are relevant in the European context. The first is that the "distribution power" of a system of innovation becomes an important parameter in its success**.** If knowledge is not distributed throughout the economy, it cannot contribute to innovation in locations other than where it was generated. Distribution has two aspects. The first is that knowledge should be made available to those who have an interest in it. This is the traditional concern with diffusion. The second is that those who might have an interest in it have the skills to learn of its existence, locate it, acquire and absorb it. This is a generalisation of the absorptive capacity issue discussed above.

The second observation regarding innovation as recombination is that variety is a good thing. Large amounts of knowledge that are "variations on a single theme" are generally less valuable than is a stock of knowledge containing real variety. Diversity and heterogeneity in the knowledge base can be vital in allowing a potential innovator to move out the product development trajectory that he has inherited from the past, either developing whole new products, adding entirely new features to existing products or taking his product development in a new direction. European heterogeneity, so often decried, can in fact be an asset to be exploited when seen in this light.

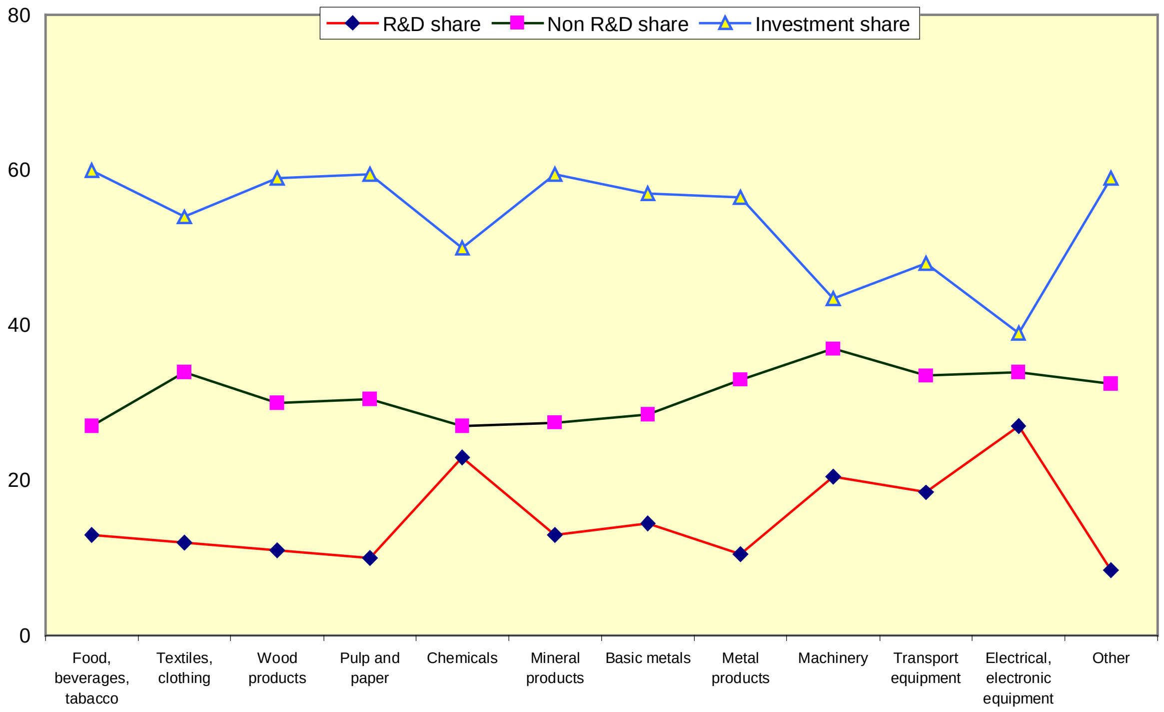
While variety emerges from the (basic) research process, it emerges from other places as well. Innovation support programmes can maintain variety by supporting the innovation that takes place through demand-side factors, applied research or instrument development.[37] Variety preservation takes place at the level of particular firms or research institutions. At that level variety emerges naturally, as every agent approaches a problem in its unique way, determined in part by its history. Thus simply fostering the technological capabilities of firms will go a long way to creating and maintaining diversity. Preservation comes from codification and archiving. In addition, firms need easy access to this variety. This turns on the distribution power of the innovation system.

[37] See De Solla Price (1984) or Irvine (1991).

### II.2.4.2 Innovation and Learning Occur in Many Locations

According to the results of the Community Innovation Survey, R&D expenditures range from between 10 and 25% of total innovation expenditures. The rest is taken up by investment in physical and software capital, training, design and market introduction (see Figure II.1 for innovation expenditures in selected industries).

**Figure II.1 Composition of innovation expenditures by industry (percentage of total innovation expenditures)**




Source: CIS 1992

This suggests that there may be considerable innovation without formal research. This notion fits very well with many of the changes in our understanding of innovation described above. The systems approach to innovation implies that knowledge is generated in many locations in the economy. In principle, then, a firm can innovate by making use of knowledge generated elsewhere, either by other firms or by other types of institutions. This activity may not be precisely innovation without research, because some of the knowledge or information used by an innovating firm may have been generated by other agents' research, but it may well count as "innovation without the innovator doing research". However, there are more clear cases. Learning by doing is a form of innovation, and one in which knowledge generation is a by-product of production. It is a phenomenon the details of which are not well-understood, but something is being learned during production which improves the production process. This phenomenon has been known for many years.[38] Learning by using is another source of innovation without research. Here, use of a good, and communication of the users' experiences to the producer result in improvements to the product — product innovation.[39] As users, and sometimes designers of products, governments are part of this process of learning outside research. Indeed, because of their size, governments are major procurers of technologies: studies have show that of 2000 innovations in Canada introduced between 1945 and 1978, the public sector (sometimes jointly with the private sector) was first user of fully 25 percent. More striking, of innovations in communications equipment and in electrical industrial equipment, governments were first users of 40 and 33 percent respectively.[40] Thus it is essential, if this is to contribute positively to the innovation system, that governments be sophisticated consumers. This involves not only the procurement decision, but also, and much less obviously, the sorts of feedbacks that flow from the users, policy-makers themselves in many instances, to the suppliers of the technology. Rapid, extensive and sophisticated, informative feedback is essential if learning-by-using is to be strengthened.

### II.2.5 The Rapid Rise of the Knowledge or Science-Based Firm

Knowledge-based firms are more and more obvious in the economy, particularly in industries like biotechnology, software, advanced chemicals and so on. Characteristic is that these firms have much knowledge and similar intangible assets in house, but no output to show at the time start-up financing is required. The majority of their assets reside in the brains of the founders. In this they are similar to professional sports clubs in owning virtually no tangible, physical capital, but having all of their capital reside in the skills of their employees.[41] This makes if very difficult to assess the market value of these firms. Because of the nature of the labour market for professional athletes it is even easier to assess the value of a football club than it is to assess the value of a (new) knowledge-based firm. To assess the value and potential of the skills (or new ideas more particularly) that make up the assets of these firms, financiers need a way to identify that the knowledge exists, and that it has economic value. The ability to make these assessments itself demands specialised knowledge of the field.

> Rapid, extensive and sophisticated, informative feedback is essential if learning-by-using is to play a strong role in innovation.

The difficulty this causes in the case of mature firms is manifest in the current inability of experts to explain stock-market valuations. Part of this difficulty stems from the fact that there are no standardised forms of recording intangible assets. Information about intangible assets and investments in them tends to be generated by surveys of firms. This implies that the information is not useful in firm level analysis, and further that it is not current—it tends to take several months from the completion of the survey to the release of results. While this

[38] See Wright (1936) as the first well-known example.

[39] This phenomenon has been documented by Nathan Rosenberg (1982).

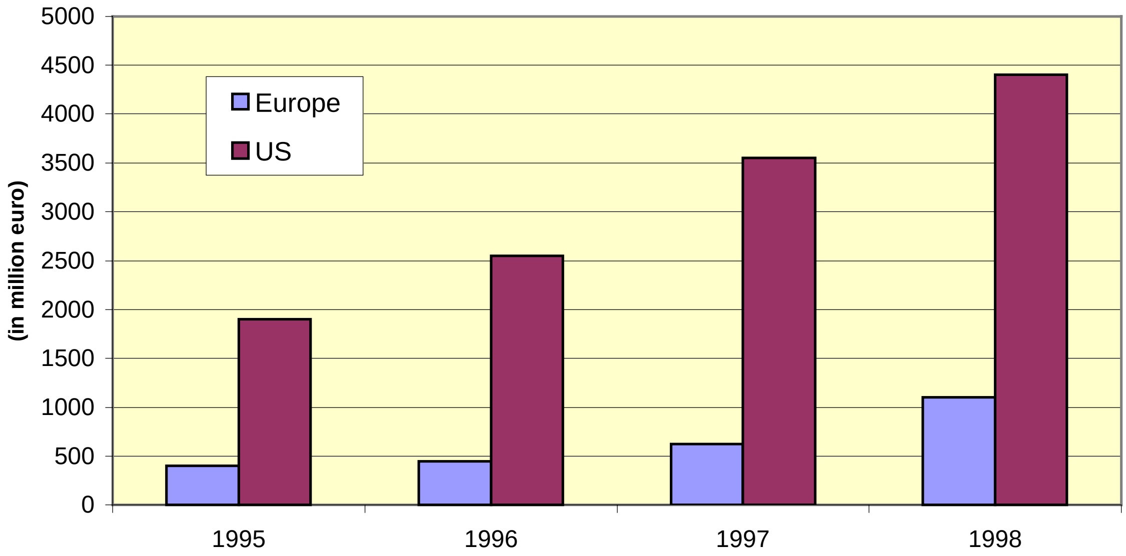
[40] Dalpé and DeBresson (1989).

[41] One difference between firms and football clubs is that a firm can patent or copyright, thereby assert property rights over, some of the knowledge or skills developed by its employees, whereas a football club is unable to prevent other teams from imitating its "offside trap".

implies some difficulty even for policy making, it even more implies that the data are too old to be useful in market valuation of firms. A standardised presentation of intangible capital and investments in the financial statements of firms would alleviate both of these problems.

From the point of view of innovation policy, however, the difficulty in market evaluation of firms is even more important when evaluating new, small firms. Inability to assess the value of an idea will make a risk-averse investor eschew an investment in it. This is the role of the venture capitalist. But in Europe there seems to be a shortage of venture capital. As a percentage of GDP, venture capital in Europe is roughly half that in the US.

**Figure II.2 Early-stage venture capital investments in the EU and the US, 1995-1998 (in million euro)**




Source: EVCA

There is a second difference between Europe and the US in this regard, which is that venture capitalists in Europe tend to skew their investments much more heavily towards firms with proven track records. In Europe "early stage" capital accounts for roughly 15% of total venture capital; in the US this number is roughly 40%. Figure II.2 shows the lag in early-stage venture capital in Europe.

It must be noted that while venture capital is very important in the US, and this fact creates concern among European policy makers, venture capital is of almost no importance in Japan. This implies that successful innovation can be built on a variety of financial structures. It is not necessarily the case that Europe should be trying to imitate the US in this regard. Europe should look for its own financing mechanisms, which take advantage of its current strengths and idiosyncrasies, while alleviating existing bottlenecks. A recent study of Dutch software firms indicates that start-ups, now small to mid-sized firms, did not in general experience a shortage of venture

> Europe must look for its own financing mechanisms, which take advantage of its current strengths and idiosyncrasies, while alleviating existing bottlenecks.

capital.[42] This could suggest that demand for venture capital may not, in Europe, be as strong as it is in the US, and that other forms of financing better fit the European system.

## II.3 Four Main Themes

The discussion in this chapter has emphasised five changes in the way we view the innovation process. A more sophisticated understanding of the nature of knowledge; a renewed interest in the importance of clustering in innovation activities: advances in our ability to model the micro-economics of the innovation process; emphasis on the multiple sources of knowledge creation and innovation; and observations of the growth of the knowledge- or science-based firm. Throughout the discussion of these changes in our understanding, though**,** four main themes can be detected.

The discussion about the nature of knowledge exposed, again, the importance of issues surrounding the distribution power of the system, that is, its ability to diffuse knowledge to those who need it. This discussion also emphasised the importance of humans as holders and carriers of that knowledge. The renewed interest in innovation clustering is also closely related to issues of diffusion, since it is difficulties in diffusion that give clustering its impetus. Similarly, the new micro-economic models of knowledge use and transmission rest on more detailed exposition of transmission mechanisms, and again the ability of human agents to absorb the knowledge they receive. Closer examination of the multiple sources of knowledge creation and innovation has revealed that the knowledge bases on which innovating firms rest their activities have become broader and more complex. Variety in diffusion of and access to knowledge must be seen as vital, and innovation without research is an idea that has gained prominence. Finally, the rise of the knowledge- or science-based firm has created issues in measurement of economic assets, and again has called attention to the importance of humans, this time coldly as economic assets, in the knowledge-driven economy.

The four themes that we pick up explicitly in our policy discussion in chapter 4 are:

1) Diffusion of knowledge is a key element;

2) Innovation without research needs attention;

3) The complexity of the knowledge base;

4) Humans are central as holders of (vital) knowledge assets.

[42] Van de Paal (2000).

# CHAPTER III. SELECTED THEMES: INNOVATION IN A GLOBAL CONTEXT, INNOVATION IN SERVICES AND THE ROLE OF INTELLECTUAL PROPERTY RIGHTS

## III.1.1 Innovation in a Global Context

The process of European integration is not just limited to the creation of a customs union, a common agricultural policy or a single currency. It is also based on the creation and dissemination of knowledge, both between individual Member States, and within Member States. However, in a knowledge-driven world economy, it is increasingly difficult to consider Europe and European Member States as being separated from the rest of the world. The dissemination of new ideas, know-how and technical expertise respects neither the frontiers of individual states nor European frontiers. Inventions and innovations are transmitted from one part of the world to another with an unpredictable pace. A crucial question therefore is "How does globalisation change the nature of the knowledge generation process in Europe and elsewhere? And related to this "How is Europe doing in this area?" This section seeks to address the following issues related to the globalisation of innovation:

- To identify the various meanings of the so-called 'globalisation of technology';
- To report some empirical evidence on the various forms of the globalisation of technology;
- To explore to what extent and in which direction the globalisation of technology is affecting the European Union;
- To assess the role of science, technology and innovation policies carried out at the European level for the benefit of European welfare, competitiveness and growth.

### III.1.2 Various Aspects of the Globalisation of Technology

Much research has been devoted to the globalisation of technology. The globalisation of technology concerns us here in two aspects. Firstly, there is a convergence between countries in the kinds of knowledge being used. Secondly, there is a rapid convergence in the way in which knowledge is created and disseminated. Contrary to what is produced in the popular press, globalisation of technology is not solely about the effect of new technologies, particularly information and communications technologies (ICTs). They have, however, played a significant role in accelerating the globalisation of technology. For instance, new technologies are a fundamental vehicle for the transmission of information and knowledge across different regions. Without the Internet, satellites and new telecommunications technologies it would not be possible to transfer information, at low or negligible costs, from one part of the world to another. However, ICTs should be seen as one of the determinants of globalisation, but also as a consequence of globalisation.

In recent years, economists have attempted to disentangle the different aspects of the globalisation of technology.[1] The resulting taxonomy consists of three main categories:

- the international exploitation of nationally-produced technology;
- the global generation of innovations by multinational enterprises (MNEs); and
- global technological collaborations.

The aim of this taxonomy is to classify individual innovations according to the main methods used to generate and exploit them. The categories are therefore not mutually exclusive at the firm level.[2] Enterprises, especially large ones, generate innovations, which fit into each category.

*International exploitation of nationally-produced technology*

The first category includes the attempts of innovators to obtain economic advantages by exploiting their technological competences on markets other than the domestic one. This category can be labelled “international” as opposed to “global” since the innovation introduced preserves its own national identity, even when it is diffused and marketed in more than one country. Both large and small firms take part in this form of internationalisation, although large firms are generally better equipped to commercialise their innovations in foreign markets. Smaller firms may prefer to exploit their technological competences in international markets in collaboration with other firms, or exploit them through non-equity arrangements.

*Global generation of innovations by multinational enterprises (MNEs)*

The second category is represented by the global generation of innovations. It includes innovations generated by single proprietors on a global scale. Typically, innovations produced by MNEs fit into this category. The innovations in this category are not generated in one single country but instead, are based on inputs from multiple research and technical centres, and production facilities in different countries, which belong to the same MNE. The bulk of MNEs is composed of large and often giant firms. Small firms tend to be located in a single country, and tend not to be involved in the global generation of innovation, except, again, through collaboration.

*Global technological collaborations*

Recently, another form of globalisation of innovative activities has asserted itself between the two categories described above. There is a growing number of agreements between enterprises, often situated in two or more countries, to develop technological inventions together.[3] The need to cut the costs of innovation, but also other motives, have created new forms of industrial organisation and new proprietary arrangements, which are now expanding

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[1] See Archibugi and Michie (1995, 1997), Archibugi and Iammarino (1999, 2000).

[2] There is an additional category, which could be added to this taxonomy, namely innovations that are generated and used within the boundaries of a state. However, since the taxonomy is designed to describe and interpret the globalisation of technology, innovations which do not cross borders are not considered here.

[3] See Mytelka (1991) or Dodgson (1993).

beyond the technological sphere. Both small and large firms are active in this form of transmission of knowledge. In particular small firms can use it as an alternative source to innovate while preserving ownership. In a way, what has happened is that enterprises have imitated a method of generating and transmitting knowledge, which is typical of the academic community. The academic world has always had a transnational range of action, with knowledge being transmitted from one scholar to another, then disseminated, without economic compensation being invariably necessary. It thereby plays, directly and indirectly, an important and increasing role to disseminate scientific knowledge and technical expertise across borders via collaborations.

### III.1.3 The Quantitative Significance of the Globalisation of Technology and the Position of Europe

Although these three modes of globalisation of technology are clearly very different, it is difficult to disentangle them empirically. In this section, we evaluate the significance of each of these modalities. We also attempt to assess how Europe is participating in these processes, what the impact is of each of these forms and what the policy implications are.[4]

#### *III.1.3.1 International exploitation of technology*

For a quantitative assessment, it is useful to distinguish between the embodied and disembodied components[5]. The former is captured by traditional international trade indicators, the latter by indicators of the transmission of know-how such as patents, trade of licences, technical assistance and so on. In general, information on the generation and dissemination of technology is not systematically collected, and we must rely on various indirect means of estimating them.[6]

A majority of technological activities of firms continue to be conducted in their home location. Small firms tend to be less internationalised than larger firms, because they have more limited resources, and consequently, concentrate their high-value adding activity at home. However, even large firms, which are otherwise international in scope, develop a substantial part of their product and process innovations in the home country and only subsequently exploit them internationally. Patel and Pavitt estimated that 89% of all R&D expenditures of the worlds largest firms is spent in their home location, with patenting activities due to foreign-based research increasing at a modest 2.4% since the mid-1980s.[7] This increase primarily represents the consequences of foreign acquisitions rather than of an increase in 'green field' investment in R&D overseas.

[4] It should be noted however, that in the majority of cases, the available indicators do not provide full information on the various categories of globalisation distinguished here. In some cases, the indicators include heterogeneous dimensions, in other cases they do not cover all the dimensions. Nevertheless, the evidence discussed here informs on the significance and trends in the various aspects of the globalisation of technology.

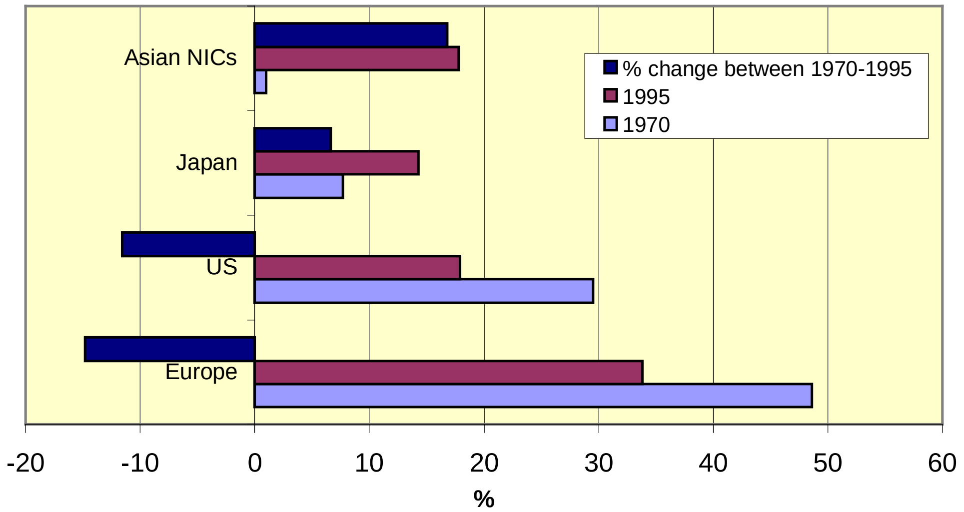
[5] We define disembodied knowledge as knowledge, which is disentangled from the product or service itself, for instance through patents or licenses. Embodied knowledge can be defined as knowledge, which is captured in products or services

[6] See Evangelista (1999c).

[7] See Patel and Pavitt (1998).

Although all commodities include a technological component, there are some which are more technology-intensive than others. About one fifth of all world trade in 1995 was estimated to be in the most technology intensive sectors (referred to as science-based sectors). This share has more than doubled in the last twenty-five years. Over the period 1970-1995, the European share of science-based exports as a percentage of total world exports in these sectors has declined from 48.6% to 33.8%.[8] Although the US share has also fallen, the decline has not been as large. By contrast, the share of Japan and the Asian Newly Industrialised Countries (NICs) increased over the same time period from 7.7% to 14.3% and 1.0% to 17.8% respectively (see Figure III.1).

**Figure III.1 Share of "technology intensive" exports as a percentage of total world exports in 1970 and 1995 (and the % change between these years)**




Source: Fagerberg, 1999. The figure for Europe includes intra-European trade. Trade in services not included.

However, the European share of world exports is increasing in raw materials and agriculture. Overall, the prognosis is that European industry is, broadly speaking, losing competitiveness in terms of high-technology sectors, although it seems to be maintaining its position in lower technology sectors.[9]

Patent statistics and, in particular, international patent flows, are indicators of disembodied knowledge streams. Patents can be extended in foreign markets both to sell a product that embodies the innovation and to sell the innovation in a disembodied way. Each patented invention is, on average, extended in three countries. A robust growth rate in patenting has occurred over the 1985-95 decade, equal to 13.3% a year.[10] This growth rate has been substantially higher than the growth rate of industrial R&D expenditures, indicating that the trend in external patent applications cannot be related to an increased investment in technology, but results from increasing attempts to exploit the results of innovation in overseas markets. Firms seek to appropriate their technological investments increasingly on a global scale. European firms also participate in this general trend. They increasingly operate

[8] See Fagerberg, Guerreri and Verspagen (1999).

[9] As argued in chapter 2, the technological intensive part of economy is not the exclusive user of knowledge in an economic system.

[10] See Archibugi and Iammarino (2000) forthcoming in: Chesnais, Iett-Gillies and Simonetti (2000).

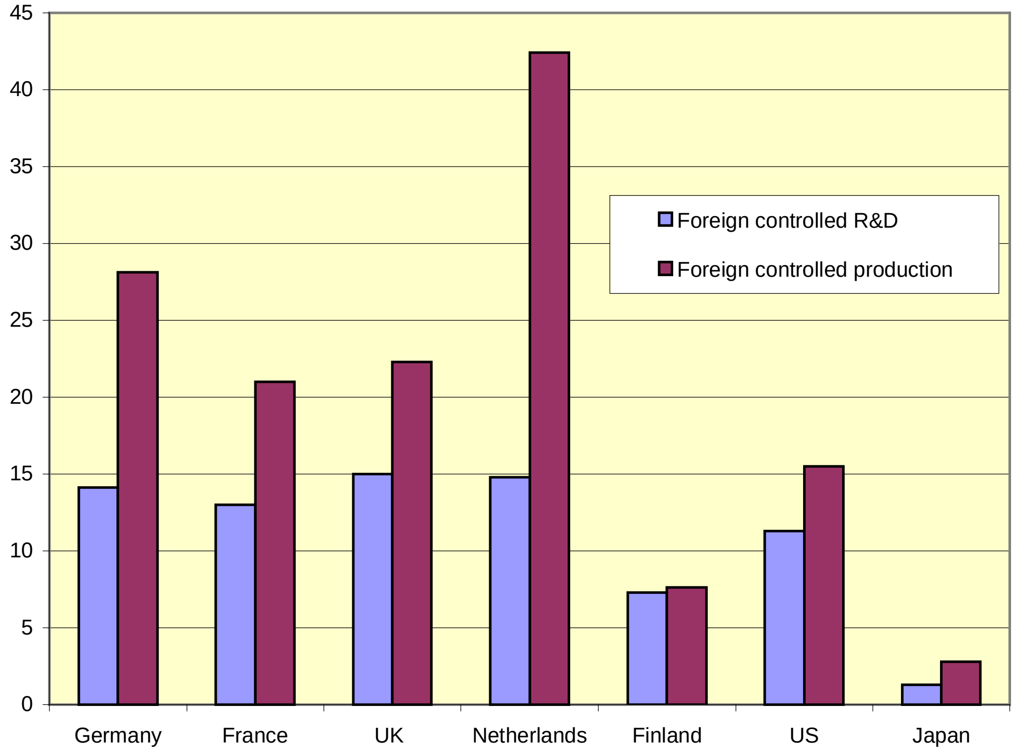
in several national markets and this is also reflected in the larger number of patent extensions observed. In spite of the available institutional arrangements, the European firms are certainly disadvantaged by the fact that, in order to exploit their innovations across the European Single Market, they have to deal with different institutions and legislations.

### *III.1.3.2 Global generation of innovations by MNEs*

The evidence collected on the activities carried out by MNEs in host countries is more systematic, although still rather fragmentary. In order to examine the European situation with regards to the global generation of innovations of MNEs, we need to take into account the two facets of innovation by MNEs: the innovative activities of foreign firms that operate in the EU, and the innovative activities of European firms that operate outside the EU.

In the three largest European countries, Germany, France and the United Kingdom, foreign firms account for 14.1%, 13.0% and 15.0% of the total business R&D expenditures in those countries. By contrast, foreign-controlled *production* accounts for 28.1%, 21% and 22.3% respectively.[11]

**Figure III.2 Importance of foreign firms in various countries (foreign R&D and foreign production as a percentage of total national business R&D expenditures, and total national production, in those countries)**




Source: Patel and Pavitt, 1998. (Foreign controlled production figures are for 1994, foreign controlled R&D figures are for 1991 (Japan), 1992 (France), 1993 (Germany) 1994 (UK and US) and 1995 (Finland and the Netherlands).

[11] See Patel and Pavitt (1998).

Foreign affiliates tend to play a more significant role in the economies of 'smaller' economies (either in terms of population or GDP), but in general, foreign-owned firms are responsible for between 10 and 20% of R&D expenditures. Nonetheless, Europe does not appear significantly different in this respect from the US, where foreign firms control about 11.3% of R&D and 15.5% of production.

The overseas R&D activities of European firms tend to be concentrated primarily in the US. This is so for several reasons. Firstly, the US is an important market for European firms. Secondly, European firms have had a traditional presence in the US, and as such are embedded in the local US economy. Thirdly, US-based firms are at the technological forefront in many high technology, and technology intensive sectors. European firms often establish R&D facilities in close proximity to their US competitors to benefit from spillovers, and to augment their existing assets. In other words, firms often establish foreign R&D activities with the aim to acquire new assets, in addition to R&D that helps to exploit their existing assets. Indeed, the importance of US-based R&D facilities to European firms is associated with both of these motives: European firms account for almost 70% of the foreign-controlled R&D in the US.[12]

The question that arises from these discussions is: are there any R&D-based reasons why a nation should prefer foreign firms to domestic ones? In other words, are foreign MNEs generally keener than domestic enterprises to invest in R&D? One way to check this is to compare the R&D intensity of national firms and foreign affiliated firms. In the US, home and foreign firms have the same R&D intensity in certain industries, but overall, as in most other OECD countries, with the exception of Australia, the ratio of R&D expenditure to sales of foreign affiliated firms is lower than for national firms.[13] In all European countries, the R&D intensity of national firms (the so-called national champions) is substantially higher than that of foreign firms. In Germany, foreign affiliated firms report a ratio, which is only half that of national firms (it is, however, significant to note that in Germany foreign affiliates have a high R&D intensity compared to other countries). In other words, there is robust evidence that domestic firms are more R&D intensive than foreign ones.

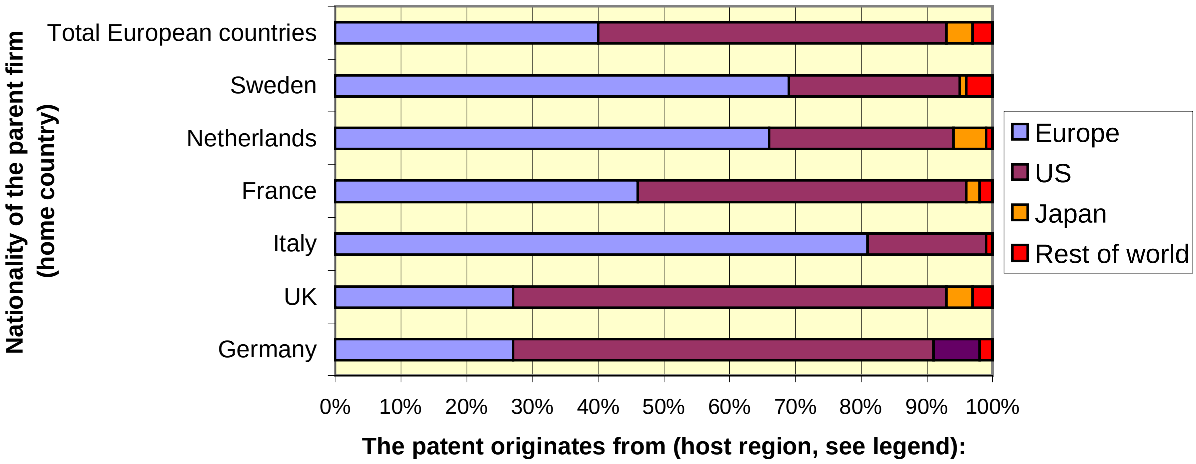
Attracting foreign-owned R&D is generally regarded as a potentially positive development by most host economies. There is abundant evidence that R&D centres tend to agglomerate. High R&D activity by national firms might therefore induce the localisation of foreign firms and vice versa.[14] Indeed, the R&D intensity of foreign firms is higher in those countries where the R&D intensity of national firms is also high. Some evidence on the share of innovative activities carried out outside home countries, based on US patent statistics is available.[15] This shows that, by far, European firms as a whole have a much larger share of patents granted from foreign subsidiaries than those from the US and Japan (34.8% versus respectively, 8.6% and 1.1%). Hence, large European firms are much more international in the scope of their innovative activities than their American and Japanese competitors.

When European firms locate their R&D in foreign countries, the preferred locations are either other European countries or the United States. Evidence, based on patent statistics for the period 1990-1995, considers innovations developed in foreign countries by European firms:

[12] See Dunning and Narula (1995), Kuemmerle (1997), Serapio and Dalton (1999).
[13] See Dunning and Narula (1995), OECD (1997b).
[14] See Cantwell (1995).
[15] See Cantwell and Janne (2000).

40.4% originate in other European countries; and 53.1% originate in the US. Only 4.3% of the innovations developed by European firms come from their Japanese subsidiaries. There are also significant variations across European countries, as is shown in Figure III.3.

**Figure III.3. Patenting activity attributable to European-owned research outside the home country, by host region and nationality of the parent firm (1991-1995)**




Source: Cantwell and Janne (2000).

In the case of German firms, 65% of the innovations of the foreign subsidiaries originated in the US and 26.9% in Europe. In the case of Dutch firms, the innovations developed in US subsidiaries accounted for 28% and those in non-Dutch European subsidiaries for 65.7% of the innovations of the foreign subsidiaries. Other countries, which seem to concentrate their activities within Europe are Italy, Belgium, Norway and Sweden.[16]

What determines the preference for one R&D location over another? Several different factors impinge. First, the underlying motives vary – R&D may be conducted to exploit or augment existing assets, or to develop new assets. Where the primary purpose of the R&D facility is to engage in basic or applied research or to seek to develop new assets, the supply-motivated factors become significant. In a recent survey of European firms concerning their R&D location decisions, the factors mentioned were (1) the availability of high quality research professionals, (2) the presence of adequate scientific and technical infrastructure, (3) the proximity of production facilities. Also important, but of lesser significance, was the need to monitor competitors.[17]

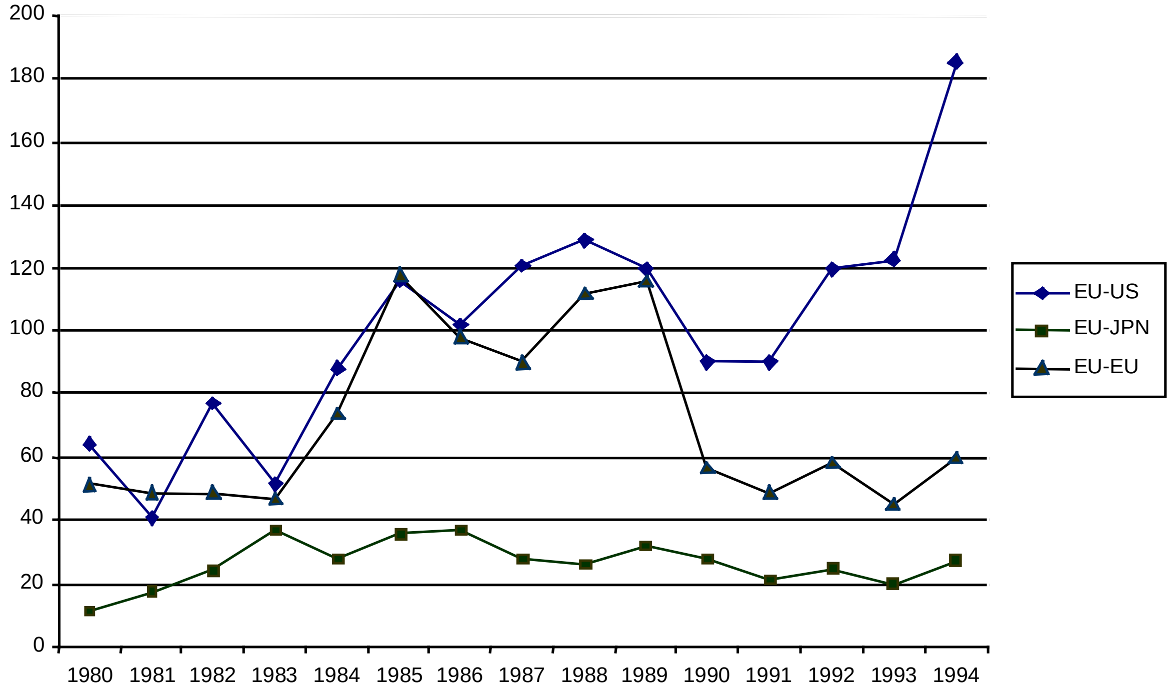
### *III.1.3.3 Global technological collaborations*

With respect to business collaboration, as many as 65% of the total strategic technology alliances recorded are international in scope. This form of generating technological knowledge has considerably increased in significance and the number of recorded agreements has doubled in a decade. The three largest economies were also the most active in technology alliances, with firms from the US, Japan and Germany being involved in 64.1%, 25.6% and

[16] See Cantwell and Janne (2000).
[17] See Narula (1999a).

11.3% of all alliances between 1980 and 1994.[18] However, despite the large involvement of US firms in technology alliances, they are, in proportion, also the least likely to engage in international alliances — only 41% of US alliances involve international partners. On the contrary, while European firms tend to be more international in their alliance partnering behaviour, they also tend to partake in fewer alliances. In addition, intra-European strategic technological alliances appear to be rather scarce. Until the end of 1980s, the propensity of European firms to engage in intra-European alliances was at the same level as their propensity for EU-US alliances. However, as Figure III.4 shows, since 1990, there has been a rapid growth in EU-US alliances, and a decline in intra-EU alliances.

**Figure III.4 Number of new strategic technological partnerships per year by EU firms, 1980-1994**




Source: Narula (1999b).

On the surface, this may suggest that EU policies to foster intra-European technology alliances have not been sufficient to reverse the preference of European partners for US partners particularly in new and emerging technologies. These trends suggest that firstly, the growth of intra-EU alliances prior to 1990 indicates that firms used this opportunity to restructure in response to various initiatives of the Commission to make European industry competitive. Evidence in an earlier study indicates that the growth in private collaboration prior to 1990 was mirrored by a concurrent increase in EC subsidised collaborative R&D. Secondly, these trends indicate the dominance of US firms in several of the new core high technology sectors. Firms of any nationality tend to partner with the best firms in a given industry, rather than based on nationality.[19]

[18] See Narula and Hagedoorn (1999).
[19] See Narula (1999b), Hagedoorn and Schakenraad (1993a,b), Narula and Hagedoorn (1999).

### III.1.4 Policy Considerations

Before moving to specific policy instruments, it is important to identify public policies, at the national or European levels, that could be pursued on each of the three dimensions of technology globalisation. We should state at the outset that the basic underlying assumption of our discussion is that *it is in the interests of policymakers to promote the process of knowledge acquisition, and promote the interchange of knowledge, both tacit and codifiable.*

It is by now an accepted fact that the key to achieving nations' long run economic growth and welfare in a knowledge-driven society is to promote the accumulation of knowledge and learning opportunities. Although the benefits associated with each knowledge-intensive transaction will not always be equally distributed among the participating nations, the relevant aim of public policies should be to involve national economic agents in knowledge exchanges.

In the long run, it is not in the interest of a community to acquire knowledge from abroad systematically if it is unable to absorb the knowledge that is being acquired. That is to say, it is futile to acquire knowledge or to transfer capabilities, through encouraging firms to locate in a region if that region does not have the capacity to absorb the spillovers from the firms' activities. The human capital stock, or generic knowledge base, of that region must be sufficiently broadly-based that when spillovers occur, they are recognised, evaluated, absorbed and used. Note that this is not to propose that each country becomes self-sufficient in the generation of knowledge. No country today, not even the US, is able to produce all the knowledge it uses. Every country, and continent in fact, depends on the resources available in other countries and locations.[20] But it still remains in the interest of each country to develop some recognised strengths in technology-intensive sectors to compensate for fields in which the country is dependent on knowledge and technology is generated abroad.

In other words, *while no country can realistically be technologically self-sufficient, it must have both general and specialised technological capabilities that allow it to participate in the global interchange of knowledge*.

#### *III.1.4.1. Policy considerations: the international exploitation of technology*

It is obviously an advantage for a country to exploit its technological innovations in foreign markets since it leads to the expansion of production and of areas of influence. A larger market share, moreover, allows firms to achieve economies of scale and scope and thereby to preserve and develop its expertise. In addition, the presence of European firms in countries other than their home location provides these firms with the opportunity to expand their technological competences and acquire knowledge, which may not necessarily be available at home. This is increasingly important as most products and processes require competence in multiple technologies. There is a long and controversial practice of export incentives and today the trade rivalry is gaining importance in technology intensive sectors at the expense of traditional sectors: agriculture and materials are losing importance vis-à-vis electronics and software.[21]

[20] For a quantitative assessment, see Archibugi and Pianta (1992).
[21] See Scherer (1992) or Tyson (1992).

International trade rivalry is not only shifting within industries, it is also changing its nature and a concern of policy makers has increasingly become disembodied knowledge. Intergovernmental negotiation and litigation are more and more related to intellectual property rights violations, copyright infringements and similar issues rather than to the physical transfer of commodities across borders. Within Europe, government policies are limited by the adopted integration acts. In fact, the single market should favour intra-European trade, as the single market makes it more difficult for individual countries to protect their internal markets from imports from other European countries. The available data show that, in as much as technology-intensive products are concerned, there is also a strong propensity to trade with the US and Japan. European policies aimed at creating a European technological identity have, so far, not been successful. This fact, however, does not necessarily lead to the policy conclusion that a new European protectionism should be implemented. It seems more important to increase European production than to limit imports from other countries, because doing so reduces opportunities to acquire and develop knowledge embodied in those imports.

It would seem that countries are increasingly engaged in promoting the competitiveness of their domestic firms, in what can loosely be described as 'techno-nationalism', with the intention of developing 'national champions'.[22] Most of the major industrial economies practice some sort of government intervention to boost the technological advantages of their firms. While some governments do so through indirect means that improve the ability of location-bound resources and capabilities to attract mobile assets of domestic and foreign owned firms, others attempt more direct intervention by directly participating in the generation of technological assets.

Much of this intervention was originally a response to globalisation, with the desire to protect weak domestic firms from international competition. Ironically, this has led to a greater use of alliance and network-forming activity. As such, techno-nationalism is doomed to failure, as the increasingly confused question of "who is us" and 'who is them" makes such policies less and less pointed. National champions are equally willing to act as free agents, and are in some instances receiving national treatment (and support) from several governments, both national and regional. The example of IBM being involved in several research consortia funded by the EU and the US governments best illustrates this point.[23]

There is also a strong need to redefine the rules for the trade of disembodied knowledge. One important step would be to agree on a common patent law, but we should also be aware that crucial components of contemporary knowledge, including software, are outside the scope of patent protection. A legal design for intellectual property rights protection in Europe is therefore substantially wider than can be provided by patent legislation. While large firms easily have their own international networks to buy and sell know-how, small firms need support for both commercialisation of their innovations and to monitor the international technological developments that might be relevant for their business.

#### *III.1.4.2. Policy considerations: the global generation of innovations by MNEs*

What should be the attitude of governments towards: a) national firms locating their R&D and innovation centres abroad; and b) foreign-based MNEs investing in R&D and innovation at home?

[22] See Ostry and Nelson (1995).
[23] See Reich (1990) or Narula and Dunning (1998).

There are both advantages and disadvantages associated with each of the two aspects. On the one hand, it is certainly an advantage if MNEs hosted in a country also invest in innovative projects and contribute to up-grading domestic technological competence. On the other hand, there is the danger that the activities of MNEs will crowd out those of national firms. However, the risk of crowding out national firms is much more associated with foreign direct investment (FDI) in the country than with the *technological component* of FDI. Governments might have their own reasons to encourage or discourage FDI, but once FDI is hosted there is certainly an advantage to adopt policies to foster a strong technological component.

There is clearly a concern about sovereignty and national or regional security in certain industries, when R&D carried out by MNEs increases the dependency of the nation on the strategic choices of foreign firms, which may have preferential ties with the governments of their home country. Once R&D investment by MNEs is accepted, there is a wide range of public policies to minimise such risks. Blocking FDI is no longer an option under the protocols of the World Trade Organisation, and globalised markets make any direct intervention futile, or at least very expensive.

Globalisation makes it much more difficult to identify what constitutes a national champion, as has proven to be the case with ICI or Rover. With the world-wide process of mergers and acquisitions in many industries, it is becoming increasingly difficult to identify large MNEs with a single nation background. Although Volvo may be owned by a US firm, its products and production facilities are quintessentially European. Policies that have sought to create national champions have actually furthered the process of transnationalisation, since barriers to imports have encouraged foreign MNEs to establish local value adding activities, and to undertake alliances in order to receive national treatment.[24]

R&D by foreign MNEs should be seen not as a threat, but as an open window into technologically dynamic countries, which strengthens the competitive position of national firms in new emerging areas.

In terms of domestic firms relocating R&D to other countries the reasons, which induce firms to locate overseas part of their R&D and innovative activities should be explored. Sometimes this can be related to the lack of the adequate infrastructure or human resources in the home country (and this will have direct policy implications). If, on the other hand, national firms consider it important to keep a window open on the technological advances in other countries, it is important that public policies aid in the domestic dissemination of know-how acquired abroad.

An important question to be answered through future research is therefore: “What are the motives for European firms to conduct R&D in the US, rather than in other European countries?” And related to this, “should this be of concern to the EU?”

As stated above, only *large* MNEs tend to generate innovations globally. Small and medium sized firms do not generally use this channel since they do not have the financial resources to invest in overseas R&D labs. But this does not imply that small and medium sized firms do not have a need to acquire technical information from abroad. They might sometimes manage to bridge the gap by using other forms, most notably cross-border collaborations. However, even this option is somewhat limited, as considerable resources are needed to conduct

[24] See Ostry and Nelson (1995).

collaborative activities, which are not normally available to small and medium firms. There could be a role for future European innovation policy here.

### *III.1.4.3. Policy considerations: global technological collaborations*

In the case of global technological collaborations, the distinction between inward and outward flows disappears since each country involved in a collaboration simultaneously receives and provides expertise. Of the three forms of the globalisation of technology discussed here, this is the most typical example of a positive sum game, since the members involved can manage to increase their expertise and the externalities associated with it.

This does not mean however, that the advantages and disadvantages are equally distributed among the participants. As in many marriages of convenience, one of the partners can easily take advantage. In particular, it is likely that the learning potential of each partner will be different. The partner with greater knowledge will have more to teach but it will also be quicker in learning from others and vice versa. Public authorities are not in the position to detect the learning potential associated with each individual collaborative agreement. It is much more important for a country to become a junction for the exchange of knowledge and technical expertise than to secure returns from each exchange.

The bulk of the financial resources of the European Union have been devoted to schemes of collaborative nature. This has however been combined with the competitive selection of projects. In other words, the European Union has tried to select the best projects among those applicants willing to collaborate with teams in other countries. There is a strong economic rationale for doing this. First, the competitive nature of the selection process should help to fund the best projects. Second, the requirement of cross-border collaboration helps to disseminate and diffuse knowledge across regions. Apparently, the European academic community is keener than the business community to engage in international collaboration. This suggests that policies, which will increase public/business co-operation in Europe might also lead to increased international co-operation among firms.

It has often been discussed whether the financial schemes to foster collaborations and partnerships of the European Union should be limited to member countries or should also be open to prospective collaborators from other regions, and most notably the US. The view here suggested argues that the key discriminating point should be associated to learning: it might be in the interest of Europe to involve and fund the participation of selected non-European partners if this provides additional knowledge to Europe.

What opportunities are there for EU innovation policy regarding R&D collaboration, which may complement the innovation policy of member states? First, one of the most important roles on a supra-national level is to help to guarantee a market for the output of R&D alliances. Policy makers must ensure, however, that these sorts of actions do not excessively tilt the market in favour of one technology or product type over another — the danger there arises from the possibility of selecting a sub-optimal technology, rather than the best one. Second, EU policies can help to reduce the difficulties that small and medium-sized enterprises experience in participating in cross-border collaboration. A large proportion of the EU collaborative efforts have been undertaken by large firms. This is partly because the administrative costs associated with EU-subsidised R&D collaboration are very high for SMEs, and these could be reduced by concerted efforts to streamline and standardise regulation. Third, it can help to improve the “market for partners”. In particular, it can encourage large firms to co-operate more intensively with SMEs by making such participation conditional for future funding.  SMEs often may have a strong technological position, but  are unable to find the “right” partners.

## III.2.1 Innovation in the Service Sector

This subsection discusses aspects of the knowledge economy related to innovation in the service sector. The relative size of the service sector in Europe has been increasing for decades, but consensus exists that there remains potential for significant further growth in employment and output. As the weight of the service sector increases in the economy, its growth rates will be more important in determining economy-wide prosperity. Thus innovation, historically one of the keys to economic growth, must be understood within the context of the service industries, and their interactions with the knowledge economy. In this section we examine several related aspects of innovation in services.

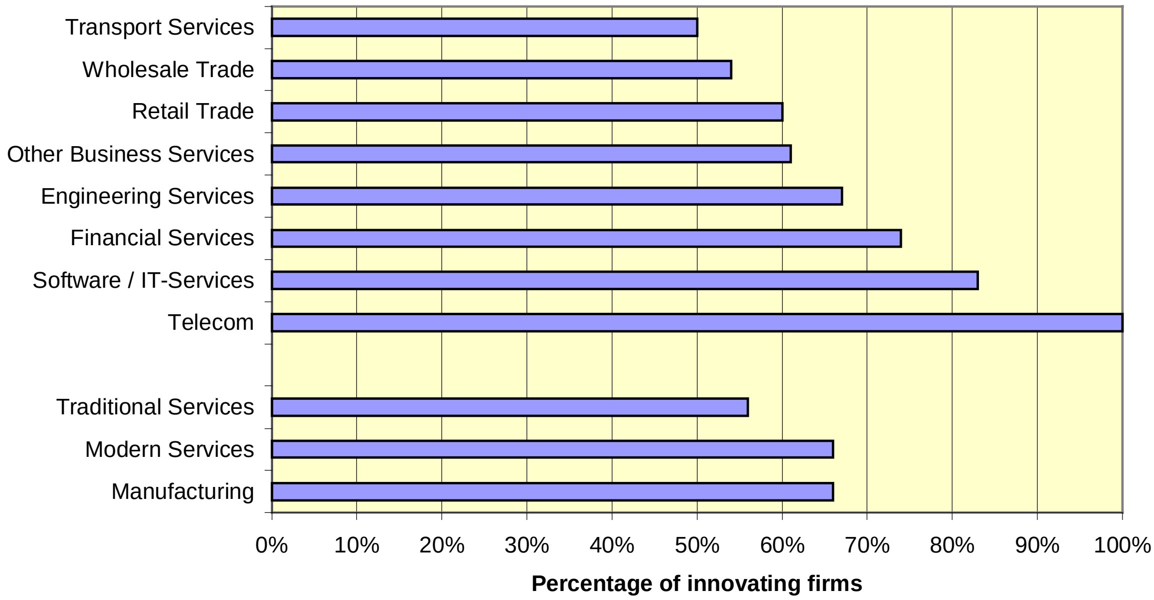
Data-gathering on innovation in services is still in an embryonic stage and as a result, data are quite rare. In 1998, EUROSTAT initiated a large effort to generate data by expanding the community innovation survey (CIS) to a wide range of market services. This can significantly increase our understanding of innovative activities in the service sector. However, data resulting from this endeavour are not yet available for most European countries. As data of CIS II remain generally unavailable at the micro-level, many of the data used in this section are drawn from the German Innovation Survey in Services (first and the second wave of the Mannheim Innovation Panel for the Service Sector: MIP-S). Most of the conclusions are valid for other European countries since the driving forces of innovation in services (diffusion of ICT technology, deregulation, and increasing tradability of services) are the same in Germany and other European countries.

The service sector is a rather heterogeneous collection of industries. It is therefore often difficult to make general statements or to come to simple conclusions. We will concentrate attention on industries that are market-based in most European countries, and for which survey data are available. We do not consider in the first instance innovation e.g. in the health sector or in public services, which are certainly very important arenas for innovation and also have a strong impact on innovation in other sectors of the economy (e.g. medical equipment, pharmaceuticals).

### III.2.2 On the Nature of Innovative Activity in Services

The current wave of innovation in services can be explained in large part as a response to shocks exogenous to the sector. Deregulation in many areas and the rapid development and diffusion of information technologies have opened markets to international competition. In addition, manufacturing firms are re-establishing a focus on their core competences and increasingly source out ancillary service activities. Taken together, these developments increase competition in services and create opportunities for firms to improve their market positions by introducing new products, and to enhance their efficiency by introducing and reinventing their production processes. We would therefore expect to find the largest share of innovating enterprises in those sectors where the changes of market conditions undergo the most severe changes.[25] This is indeed the case, as seen in Figure III.5, which plots CIS II data for Germany.[26]

**Figure III.5 Share of innovating firms in selected German service industries**




Source: CIS II data

Innovation is no longer solely the domain of manufacturing industries, as the aggregate data in the bottom of Figure III.5 indicate.[27] Innovating firms are as common in services as they are in manufacturing.

## III.2.3 Structure of Innovation in Services

While services and manufacturing look similar in terms of numbers of innovating firms, there are considerable differences in the structure of innovation activities between the two sectors**.**

Raw survey results indicate that process innovations are less common than product innovations in the service sector. Half of the surveyed firms refer to themselves as product innovators and only 35% as process innovators. These results must be treated carefully, though. In services particularly, the line between product and process is not at all sharp, and

[25] Innovating enterprises are defined — according to the Oslo Manual — as firms that introduce new or significantly improved products and/or implement significantly new production process within a three years period (1994-1996).

[26] Similar results are presented by Klomp and van Leeuven (1999) and Evangelista (1999b). CIS-II data for other European countries are consistent with this pattern, though some notable differences do exist between EU states.

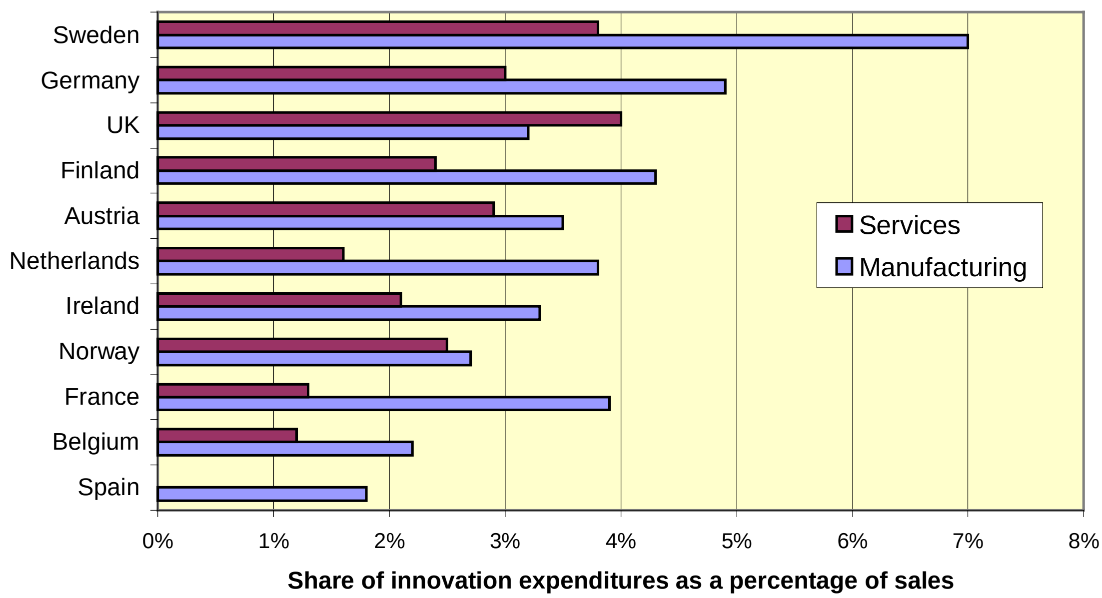
[27] Data for these aggregates refer to the year 1997. For details see Janz *et al*. (1999a, 1999b).

case studies, for example of banking, suggest that firms' self-assessments underestimate the importance of process innovation.[28]

Innovation expenditure in the service sector differs considerably in structure and in size from that in the manufacturing industry. In manufacturing, the share of innovation expenditure as a fraction of turnover constitutes about 5%; in the service sector this is only about 1%. These data for Germany are comparable to OECD data, which show that service firms spend less (as a percentage of sales or turnover) on innovation than manufacturing firms do. This is shown in Figure III.6.

In general, service industries spend less on research and development, again as a proportion of sales, than do manufacturing industries, and R&D seems to play a very small role in services innovation. Exceptions exist, though: firms in technical and IT service sectors are similar to technology-intensive firms in manufacturing. For example, according to the German CIS II survey, approximately 65% of the innovative IT service providers and about 45% of the innovative technical service providers carry out R&D, compared to only 14% in the service sector as a whole, and slightly less than two thirds in the manufacturing industry. With the exception of the ICT-related industries, the relatively small amounts spent on R&D indicate that "innovation without formal research" is of relatively more importance in services than it is in manufacturing.

**Figure III.6 Innovation expenditures as a percentage of sales**




Source: OECD Science, Technology and Industry Scoreboard 1999. Data for services in Spain are unavailable.

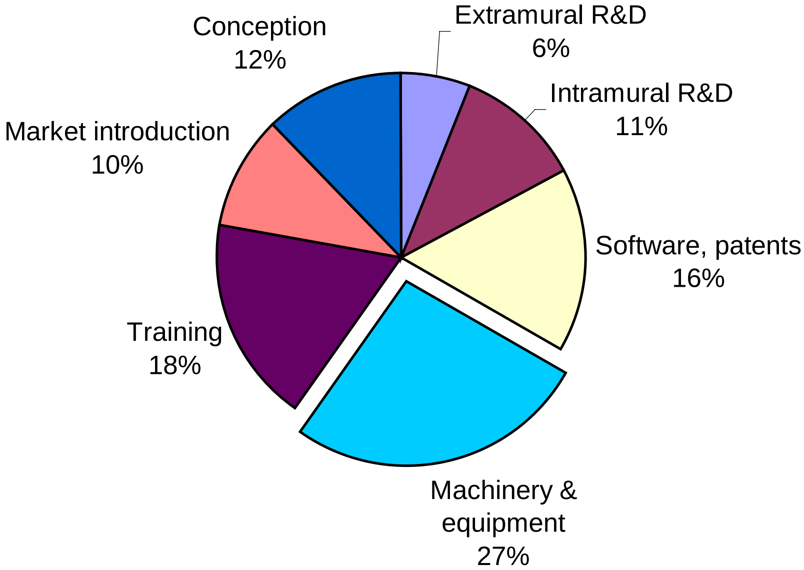
Participation in R&D activities and even more so, R&D intensity, are relatively low in the service sector. It is human capital that replaces R&D as the main input for the development and implementation of product and process innovations. Therefore, staff skill-levels are extremely important in the service sector, probably more so than they are in manufacturing. Typically, employee experience and expertise constitute the know-how of service providers.

[28] Despite these problems the distinction between product and process innovation seems to be a useful survey concept (see for more details Evangelista and Sirilli, 1995).

Since these are difficult to codify, traditional mechanisms for the protection of intellectual property play a less significant role here. In addition, product innovations are easy to copy because of their often marginal nature and a limited scope of intellectual property rights (e.g. think of the ease with which a new type of insurance policy can be duplicated by a competitor). Data for the German service sector show that investment in capital goods, mostly ICT, closely related to innovation activities amount to around one quarter of the total innovation expenditure (see Figure III.7). The service sector is the largest user of ICT and is often the lead user of new ICT technologies. This can be a very strong influence on the development of technology. Firms in knowledge-intensive and business-related services, in particular, stimulate technological change to an extent that vastly exceeds that originating in some other, more traditional, manufacturing or service branches such as transport or trade.

To summarise, innovation in services can be characterised by the use of knowledge embodied in capital goods, the use of a highly-qualified staff and a low degree of formalised knowledge generation. Investments in information and communication technologies often go hand in hand with new product and especially with process improvements.

**Figure III.7 Structure of innovation expenditures in German services, 1997**




Source: ZEW (1998) Mannheim Innovation Panel- Service Sector

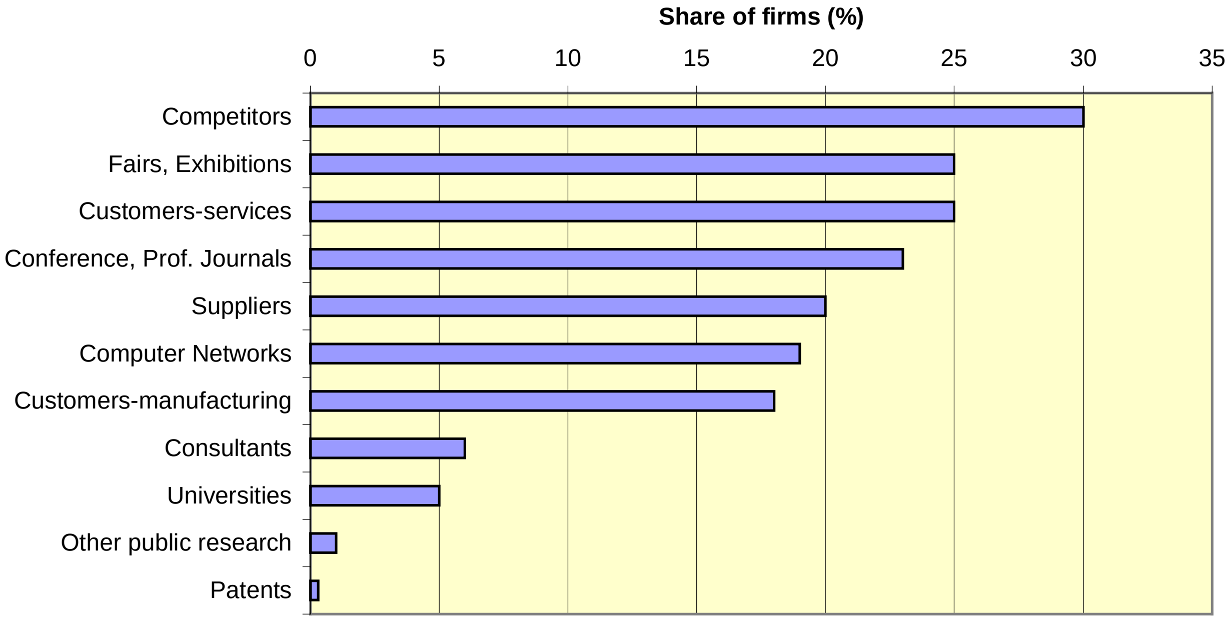
### III.2.4 Sources of Knowledge

In developing new products and introducing new processes, service firms rely heavily on their own knowledge bases. In most cases, this knowledge consists of the experience of employees and firm owners. Innovation is, therefore, largely based on tacit knowledge, stored in the minds of employees, in business and management routines. The knowledge of the staff is also indispensable for the use of external sources of information required to develop innovations within the firm. Firms have a huge variety of external sources of knowledge but Figure III.8 shows that customers and competitors are the most frequently used. Customers from the service sector are mentioned more often as sources of information than customers from the manufacturing industry. Intra-industry and intra-sectoral knowledge flows are an important part of the dynamics of the service sector, and more so than is the case in the manufacturing sector.

There is a related difference between the manufacturing and service sectors. Firms within the same line of business are relatively more important as sources of information in the service sector than they are in manufacturing. This is especially true for small companies. Analyses based on data from the Mannheim Innovation Panel suggest that there is a difficulty in creating intellectual property in services and that property rights are more difficult to defend in services than they are in manufacturing. The negative impact on the inclination to innovate and on the type of innovation introduced is obvious. Imitation of successful service innovation is easy and this lowers the profitability of investments in innovation.

Service firms are not totally incestuous in knowledge acquisition, though. Just as for manufacturing companies, national and international trade fairs and exhibitions create the possibility for German service providers to have central contact exchanges, where they meet their international customers and competitors.

**Figure III.8 Sources of information for innovation in services**




Source: ZEW (1998) Mannheim Innovation Panel - Service Sector

## III.2.5 The Inverse Innovation Cycle for Services

In many service sectors, an inverse-innovation cycle may be present. The idea was developed by Barras more than a decade ago when analysing the impacts of investment in computers on innovation in services.[29] He argued that in the initial phase of market penetration, ICT is used for efficiency enhancement; it is not until a later stage of diffusion that new products

[29] Remember at this time centralised computing using mainframes was the dominating form of IT investment.

(services) based on ICT begin to develop and to create new market opportunities to satisfy new needs. In manufacturing, by contrast, typically the first phase of the diffusion is characterised by a dominance of product innovation. In the second stage the rate of product innovation decreases whereas the rate of process innovation increases. Finally, process innovation dominates product innovation in the third stage.

In a forward innovation cycle, in which product innovation precedes process innovations, employment effects are positive in the early stages of the cycle. In an inverse cycle, by contrast, since process innovations tend to reduce rather than increase employment, early in the innovation cycle employment tends to fall, rising only later as product innovations become more important. This sequence of employment effects may or may not be visible at the aggregate level, since different firms are obviously in different phases of any cycle, which implies that cyclical effects will be much damped at the aggregate level. However, at the firm level, since often there is an identifiable beginning of an innovation, the employment effects will make labour initially resistant to change.

Part of the explanation for an inverse innovation cycle may be due to the presence of network externalities. Product innovations based on network technologies like IT are more attractive the larger is their installed base. So product innovation in IT-based service is initially retarded due to the absence of an installed base, and process innovation is more attractive. The observation made using the innovation survey — especially for the more traditional service sectors — suggests that an inverse innovation cycle is present in many cases.

### III.2.6. Innovation and Information Technology in Services

Innovation in services is based on a large range of technologies. Nonetheless, we observe that in every service industry investment in IT takes pride of place over other technological investments. The overwhelming majority of companies in the surveyed industries invests in information technology, and this typically also involves physical investments: the share of "modern services" firms investing in IT in these sectors is more or less identical to the share of firms with investment in new capital goods .

IT is not only the most important investment good; it also plays a central role for innovation in the service sector. Table III.1 shows the share of innovating companies, which state that their innovations are based upon certain technologies. The dominant role of information technologies for innovation in services is immediately clear. Even in the least IT-active sector – retail trade – 87% of the innovators believe that IT was important for the innovations introduced. The importance of other technologies varies vastly from sector to sector. New facility management techniques are important for engineers, e.g. in developing new houses. Latest traffic technologies are – of course – crucial to the transportation sector.

**Table III.1 Use of different technology for service sector innovations (1996)**

***Share of innovating firms using specific technologies to innovate***

| As share of innovating companies in 1996 | IT | Environ-mental | Facility Mgment | Traffic | Measure-ment & Control | Life Sciences | Nutrition | New materials | Other |
|---|---|---|---|---|---|---|---|---|---|
| Wholesale Trade | 88% | 45% | 27% | 49% | 22% | 6% | 5% | 21% | 4% |
| Retail Trade | 87% | 51% | 5% | 25% | 12% | 4% | 1% | 10% | 4% |
| Transport | 94% | 74% | 14% | 74% | 3% | 0% | 0% | 2% | 0% |
| Telecom | 100% | 14% | 14% | 7% | 14% | 7% | 0% | 0% | 7% |
| Banking/ Insurance | 95% | 17% | 10% | 4% | 3% | 1% | 0% | 0% | 3% |
| Software | 97% | 20% | 4% | 20% | 13% | 10% | 3% | 3% | 9% |
| Engineering Services | 96% | 44% | 28% | 16% | 27% | 9% | 9% | 24% | 8% |
| Other Business Services | 93% | 42% | 22% | 23% | 13% | 2% | 3% | 10% | 4% |

Source: ZEW (1998): Mannheim Innovation Panel – Service Sector

We already argued that R&D seems to play a much less significant role in the innovation process in the service industry than in manufacturing. The German R&D statistics show for instance, that well under 10% of the business sector's R&D is spent by service sector firms.

The question that arises is: how can service sector firms maintain an equally large share of innovating firms? One part of the answer is that innovation in service occurs mainly in the form of embodied technology stemming from manufacturing, through investments in machinery and equipment.

However, this is certainly not the whole story. More in-depth analyses show that the role of human capital for the development of innovations is important in the service sector. This can be seen by comparing the skill structure of innovating and non-innovating companies (see Table III.2).

Table III.2 shows the share of highly skilled, medium skilled and low skilled employees by industry. In all industries the share of highly skilled employees in innovating firms is larger than in non-innovating companies. Moreover, in most industries the share of the medium skilled employees is also lower in non-innovating enterprises than in innovating ones**.** This is quite similar to manufacturing. Not surprisingly, industries in which IT is important for innovation (telecom, banking, software and engineering services) have the most highly-skilled labour forces. This is true even among the non-innovating firms in those industries. In every industry, innovating firms have more highly- skilled labour forces than non-innovating firms, which underlines the crucial role that a sufficient human capital base plays for innovation in services. Further, expenditures on employee education and training are considerably higher in the industries with the most innovating firms.[30]

**Table III.2 Skill structure in innovative and non-innovative firms**

| | Non-Innovative Firms | | | Innovative Firms | | |
|---|---|---|---|---|---|---|
| **Skill Level** | **High** | **Medium** | **Low** | **High** | **Medium** | **Low** |
| Wholesale Trade | 8% | 65% | 28% | 12% | 71% | 17% |
| Retail Trade | 5% | 76% | 19% | 12% | 72% | 17% |
| Transport | 3% | 63% | 36% | 5% | 58% | 37% |
| Telecom | n.a. | n.a. | n.a. | 32% | 67% | 1% |
| Banking/Insurance | 15% | 75% | 10% | 18% | 70% | 13% |
| Software | 32% | 57% | 11% | 48% | 49% | 4% |
| Engineering Services | 43% | 46% | 11% | 47% | 46% | 8% |
| Other Business Services | 13% | 61% | 26% | 26% | 54% | 21% |

High = University or Technical University Degree or Masters Degree; Medium = Vocational Training; Low = No formal education (except school). N.a.= not available
Source: ZEW (1998): Mannheim Innovation Panel – Service Sector

These figures indicate that human capital is an important asset, and worth investing in for firms that employ IT, for firms that innovate, and especially for firms that innovate using information technology. Fully realising the benefits from investment in IT seems only possible with complementary, and often prior, investments in human capital.

Thus, the role and importance of human capital in innovation seems to be a source of differentiation between services and manufacturing. As a proportion of total innovation expenditures, spending on training is considerably higher in services and approaches the spending on R&D in manufacturing. It is worth emphasising, though, that training expenditures are not distributed evenly across all employees. Employees with higher secondary and tertiary education levels receive more training opportunities than less qualified workers.[31] In turn, as will be shown in the next section, low qualified employees represent the group of employees which, as a result of the introduction of information technology in services, suffers most in employment prospects.

### III.2.7 The Impacts of Innovation on the Demand for Skills in Services

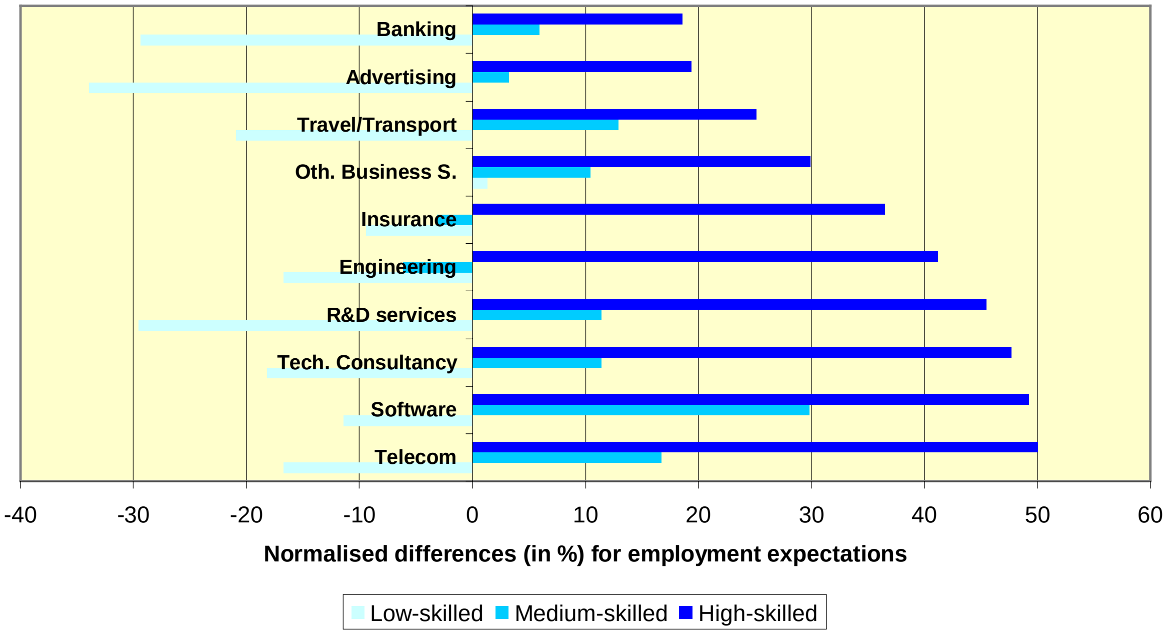
Employment expectations can be interpreted against the background of the existing staff qualification. An initial overview of general employment expectations in the various staff qualification categories shows that for Germany as a whole, with the exception of those with

[30] See the full paper by Licht (1999) for this project.
[31] See Licht and Fier (1999).

lowest human capital, labour at all qualification levels can expect increased employment.[32] Figure III.9 shows similar evidence for Italy.

These data are likely to represent an on-going trend, implying that unqualified jobs have already been lost in the service sector. And these are precisely those employees who are already affected by above-average unemployment. The hope that an expanding service industry may provide relief is frequently expressed indeed, but it is obvious that little stimulus can be expected from the sector.

**Figure III.9 Impact of innovation on the skill structure. Evidence for Italian service industries, 1993-1995**




Remark: Normalised Difference = Difference between the share of firms expecting increasing employment in a skill group and the share of firms expecting decreasing employment in this skill group.

Source: Source: Evangelista (1999a), Table 7.12

Further examination of the survey data does not provide any encouragement.[33] The more highly qualified are the employees of a firm, the less likely it is to increase its low-qualified labour. The sample shows a negative correlation at the firm level between employment prospects for the highly qualified and those for the poorly qualified. This suggests a polarisation of firms into those with highly qualified, and those with poorly qualified labour. This has far-reaching consequences for the labour market, particularly when coupled with the observation that firms' provision of continuing training and continuing education to employees is unequivocally in favour of highly qualified and already skilled employees.

Additionally, the innovation process is less markedly de-coupled from other processes than in the manufacturing sector. Attention should accordingly not be confined to training expenditures directly linked to innovation projects. The high degree of interactivity in the

[32] Licht *et al.* (1997).
[33] Licht *et al.* (1997).

process of the goods or services creation means that qualification levels and training become closely related to innovative activity and technological/organisational change in the service sector as such. We reiterate, though, that innovating companies invest significantly more in staff training than non-innovating companies. This strongly suggests that a high level of qualification is a precondition for further training/up-skilling measures in the firms.

The use of new technologies as well as the proportion of ICT-related investments in the overall investment budget exert a markedly positive effect on the level of training expenditures. Therefore, it seems dangerous when it is mainly the already-qualified staff, which profits from training (due to technological change) as it implies that the unqualified employees will be permanently excluded from the labour market, and the employment chances for the poorly qualified, slight enough as they are, will deteriorate even further as technological change progresses. Reforms of the educational systems are called for, especially since a good primary education is the ticket for further vocational education and training.

### III.2.8 Obstacles to Innovation in the Service Sector

Service sector firms have reported several obstacles to innovation. As service firms innovate, there is a growing demand for qualified labour (especially with IT-related skills) which is more and more limited by supply. Difficulties (delays, abandonment, cost over-runs) in innovation are often caused by a lack of appropriate skills within the organisation. This shortage of labour clearly impedes the expansion of knowledge-intensive services. Given the prevalence of IT as a technology used for or in innovation, this shortage cannot be ignored, and may have significant impact on the ability of the European service sector to compete. Consider the virtuous or vicious (depending on which end of the labour force one considers) cycle in which the highly qualified receive training and become more highly-qualified. Training schemes are often sacrificed when a firm comes on hard times. If European firms face a chronic IT-skills shortage, they will have difficulty competing on the world scale. The natural response of cutting "perks" like training will only exacerbate the problem, and European service firms will fall further and further behind. This is an issue that must be addressed.

Related to the shortage of skilled labour is a lack of business skills and training, particularly in project management, among the technical personnel. (In interviews managers often complain that they cannot promote their technical personnel because they entirely lack these skills.) Organisational problems are therefore a frequent reason for the prolongation of innovation projects. This deficit can be remedied by integrating elements of project management into engineering studies. This would not only benefit already existing companies, but also improve the initial situation for start-ups. Joint programmes in science or engineering and business often have the feature that graduates are neither fish nor fowl. That is, they are considered second rate both as technology graduates and as business graduates. The only solution here is to make these joint programmes longer than a simple degree, which demands, in turn, that students are financially supported for the extra duration.

Funding of innovation projects is a problem that reduces the number of projects undertaken. Therefore, efforts to facilitate access to participatory capital for innovative service providers are required. Chapter IV deals more extensively with this problem.

Technical service providers state that long administrative and authorisation procedures are obstacles to innovation. One of the most important obstacles is uncertainty, particularly regarding how long administrative and legal procedures will take. Firms also often cite what they take to be excessive administrative and legal requirements for a variety of their operations, and would, they claim, be more innovative were these to be reduced. While the second issue is in a sense more fundamental, and thus probably more difficult to change in a short time, the first is not. There are two issues. One is to stream-line the procedures to reduce the time they take. The other is simply to make the process predictable. Standardisation of procedures across jurisdictions and industries would help both of the latter problems. Complete standardisation is neither possible nor desirable, but a significant part of many of these processes should be standardised. Parallel to this, simply the systematic provision of information to firms on the functional breakdown of governmental regulation could contribute to a more realistic evaluation of how long these regulation procedures will take, since this has to be taken into account when planning projects. All of this would help to increase the efficiency of corporate innovation activities.

### III. 2.9 Policy Considerations

The policy options for the support of innovations by service providers should be directed towards the problems signalled in this section. On one hand, human capital is a key factor for innovation activities in a knowledge-intensive society. On the other, information and communication technologies are enabling technologies for the service sector, and are far more important than any other modern technology in this regard. However, particularly small and medium-sized companies in traditional service sectors such as transport and forwarding, as well as trade, often lack the ability to exploit the opportunities offered by new technologies.

Nevertheless, the growing liberalisation and internationalisation of service markets is a challenge and an opportunity for service firms. Competitiveness will be sustained only through innovation, and in services this seems to imply an increased use of and investment in information and communication technologies, and the training needed to exploit them. Innovation policy should therefore aim to increase the absorptive capacity of small and medium-sized firms and thereby stimulate the diffusion of new technologies in the service sector.

In addition, new concepts of supportive measures for the service sector must take into account both the heterogeneity of the sector and the dominance of small companies. A policy providing stable and calculable prevailing conditions is therefore of central importance.

There are indications that the staff qualification structure is shifting in favour of highly qualified people. This highlights the role of human capital in the productive process of the industries examined, and underlines the necessity for helping the less-well qualified by implementing training schemes and/or changes in the education structure. Policy at the European level can implement best-practice programmes to demonstrate and educate regarding best practice in training. It can also create European accreditation for training schemes to help firms identify the skills created by programmes with which they are not intimately familiar.

Corporate training schemes are aimed at keeping abreast of technological change. Companies with a higher proportion of highly qualified staff and users of new technologies exhibit more intensive efforts in terms of training. There are almost no discernible indications that enterprises are specifically attempting to familiarise poorly qualified staff with the use of new technologies. It is more probable that the requisite technical know-how is rather acquired through new hiring, and that in-house training schemes primarily benefit the qualified and highly qualified staff. The differences in human capital among employees are thus reinforced by training approaches during the course of ongoing technological change.

Information and communication technologies constitute the pre-eminent cross-section technology for the service sector, ahead of all other modern-day technologies. Small and medium-sized enterprises of the service sector's traditional segments (e.g. carriers, logistics and trade) often do not possess the internal resources to exploit the opportunities these technologies offer. On the one hand, technological acceleration also causes any accumulated know-how to become rapidly obsolete, while on the other hand increasing liberalisation demands intensified use of precisely these technologies in order to maintain competitiveness. This, however, reinforces the difficulties SMEs face in coping with the diffusion of IT in traditional service industries. In addition, time pressure on the side of the key personnel in SMEs in the booming business services prevent them from re-investing in human capital in order to keep up with technology. Innovation policies should accordingly aim at increasing these firms' absorptive capabilities.

The know-how available in public research institutions is important for many small and medium-sized service enterprises, which plan to use new technologies. However, formal arrangements for co-operation between SMEs and research institutions are relatively rare in most segments. Since innovation research has found that co-operative arrangements constitute an essential and frequently effective source for the transfer of know-how, the question is how such co-operative arrangements can be stimulated. The primary aim here is, as a result of altered priorities, to develop appropriate options at universities and research institutes which, in their R&D activities, still focus on industrial production/development processes.

Many service firms possess excellent preconditions for co-operative arrangements with research institutions. Thanks to the high qualification of their workforce, particularly software companies and consulting engineers are often unaffected by the most important barrier to co-operation with bodies from the public-sector institutions: unfamiliarity with the idiosyncrasies and customs of the university and academic communities. Formal and informal arrangements for co-operation are thus encountered quite often in these branches. Service firms of this kind are also very well suited for acting as a driving force to expand the relationship between public-sector research institutions and small or medium-sized enterprises from the manufacturing sector. When formulating promotional measures for SMEs in the manufacturing sector, research and technology policies should attempt to exploit this function of service-sector firms, and pay more attention to service firms' technology transfer function. In conjunction with a further diffusion of information and communication technologies, new service segments like information mediators will emerge.

In view of the exigent problems of unemployment in Europe, the development in staff qualification structures, as mentioned above, constitutes a central field of action. The transformation into a service society will entail a substantial expansion of jobs for qualified and highly qualified employees. The change in the qualification structure towards more highly qualified employees, well documented in the manufacturing sector over recent years, is manifested as a similar process in the surveyed service segments. Political measures for combating unemployment have to take account of this trend to ensure that unemployment and underemployment do not increasingly become a permanent condition for unqualified workers;

not least because long-term unemployment and technical progress will continue to devalue existing qualifications.

Efforts to improve employment chances for unqualified workers can address both the relative prices for unqualified work and the options for increasing these workers' productivity. Various policies can be applied separately or in combination. Options to decrease the relative prices for unqualified work include (1) reducing the non-wage labour costs to be paid by the companies for these workers, e.g. by cutting mandatory social security contributions, or (2) reducing earned income for unqualified work, a step whose effects on available income can be cushioned by lower income taxes for low incomes. Further, training schemes could enhance the productivity of the lower qualified employees. At present, training schemes tend to benefit mainly the qualified employees.

In any case, an increase the educational attainment of employees is a key for modern economies to profit from the job engine represented by the knowledge-driven service economy.

Finally**,** skills and knowledge of employees are very important in services innovation. This creates a dilemma for service firms. Ongoing training, especially of the most productive employees, will enhance a firm's innovative edge. (The edge here is two-fold: skilled employees can create knowledge and innovation within the firm, but they can also absorb knowledge created outside and turn it to their employer's advantage.) Training is clearly desirable. But as discussed below, training tends to be directed at those with the highest skills, which tends to create a small cadre of high-skilled, highly innovative employees within the firm. But now the firm has many eggs in a few baskets, and these baskets look very attractive to other firms. Should those employees leave, hired away perhaps, the firm has lost its edge, and worse, another firm has acquired it. This creates a dilemma at the firm level.

A firm has two responses: it can reduce its training and free ride on other firms' efforts, hiring away employees that have been trained elsewhere; or it can be active in training, *and* in keeping its employees. Both responses have social costs: the first reduces the average skill level of the labour force; the second reduces mobility and thus the distribution power, particularly as it relates to tacit knowledge.

There is, perhaps, a third strategy open to firms, which is to reduce their costs when employees leave. Such a strategy would involve codifying the knowledge that rests tacit in its most highly trained employees. This has several implications, one of which is that it then might be possible to create property rights to this knowledge, through patents or copyright. This in turn makes it possible to trade this knowledge in ways not previously possible without exposing employees to other offers. The new ICTs have reduced the costs of codification, so it may be possible for firms to pursue this option in the future.

## III.3.1 Intellectual Property Rights

Intellectual property rights (IPRs) such as patents, design registration and copyright have attracted growing policy interest in the past decade, due to the belief that we are now living in a "pro-rights" era where IPRs are considerably more important than they were in the past. Three factors are thought to lie behind an increase in the value of IPRs: changes in legislation to strengthen patents, changes in firm IPR strategies, and a shift in innovative activities from mechanical engineering towards "knowledge-driven" activities such as information technology, software, and biotechnology.

There have been two important legislative changes: New international agreements on the use of IPRs, as illustrated by WIPO (World Intellectual Property Organization) or the European Patent Office (EPO), have improved the ability of firms to extend IPRs to a larger number of jurisdictions. Second, the establishment, in 1982, of a Federal Court of Appeals for patents has made it easier for firms to protect their patents from infringement in the United States. Firm strategies that increase the value of patents in general are a shift from basic to applied research[34], and, possibly in response to the two legislative changes, a more aggressive exploitation of IPRs.[35] The European Database Directive, which includes databases under copyright law and creates new property rights for *non-creative* efforts of database manufacturers and publishers, is another indication of the current move to extending property rights, presumably as a way of creating new or stronger incentives.

The last factor is related to the rise of the "knowledge economy", which has increased the importance of competitive strategies based on innovation and proprietary knowledge. This has also involved changes in the structure of industry, as seen by the increase in investment in information-based industries such as pharmaceuticals, telecommunications, software and biotechnology. A characteristic of several of these industries is an enormous gap between the cost of discovering or developing a new innovation and the ease with which innovations can be copied. IPRs are therefore considered crucial to these sectors to permit firms to recoup the costs of their R&D investments. In addition, small firms have been one of the drivers of innovation in several new technologies such as biotechnology and information technology. These small firms partly rely on patents to signal expertise, either to attract research partners or investment. [36]

European policy makers have reacted to the apparent rise of a 'pro-patent' era with both unease and resolve. The unease comes from a widespread belief that the European 'innovation system' is unable to translate inventions into innovations as successfully as their American and Japanese competitors. And, once commercialised, European firms are unable to maintain and build upon the competitive advantages of their innovations. The resolve comes from the belief that new IPR policies could enhance the competitiveness of European firms. These policies include changes in patent law to strengthen the attraction of patents and policies to encourage European firms, particularly SMEs, to patent a higher percentage of their

[34] Kortnum and Lerner (1997).

[35] Thurow gives anecdotal evidence that large firms, such as Texas Instruments and IBM, have set up their patent departments as 'profit centres' with a mandate to aggressively pursue licensing revenue from their patented inventions (Thurow, 1997).

[36] Mazzoleni and Nelson (1998).

innovations.[37] In effect, these policies would provide a boost to the flagging competitiveness of European firms by helping them to develop and maintain their competitive advantages.

### III.3.2 IPR Policy, the Public Interest and Appropriation Strategies

Policies to increase IPR protection conflict with other policy goals to maintain and invigorate competition and to ensure that the public interest in low prices is met by minimising monopoly pricing. This raises several well-known trade-offs. The social costs of monopoly pricing as a result of IPRs is balanced by the role of IPRs in providing an *a priori* incentive to innovate and an *ex post* ability to innovate and create economic growth, based on dynamic effects when firms re-invest their excess profits in more production and R&D. The disclosure requirement for patents should provide additional public benefits by assisting the innovative activities of other firms.

The choice of the best policy response to these trade-offs is made more complex by the fact that IPRs are not the only appropriation method available to firms. The policy question then becomes: how much IPR protection is optimal, given that firms can also appropriate their investments in innovation through secrecy, lead time advantages, technical complexity, complementary services, etc? There is no reason to strengthen IPRs when other appropriation methods provide an adequate incentive to innovate. Doing so would simply increase the ability of firms to extract monopoly profits without providing any social benefits. Alternatively, are there situations in which the public interest would be better served if firms used patents rather than other appropriation methods? For example, the use of secrecy as an alternative to patents could decrease public welfare by reducing the flow of ideas among firms, thereby reducing the overall rate of innovation. The public interest could be better served by encouraging firms to use patents instead of secrecy, since the former require information disclosure. Furthermore, a dynamic rather than a static analysis might suggest that excess profits, if re-invested in additional innovation, could provide greater public benefits over the long term.

The role of patents versus other appropriation policies is not only an issue of public versus private interests. The exploitation of non-IPR appropriation strategies can be an essential component of the ability of firms to compete. For instance, a competitive strategy that places undue emphasis on patents could result in commercial failure if it leads to the neglect of complementary practices such as developing lead time advantages, frequent technical improvements, skilful marketing, and after-sales support services. An unrealistic reliance on IPRs in the appropriation strategies of firms in many sectors could result in the very outcome that European policy makers are trying to avoid: the failure of European firms to successfully commercialise their innovations. IPR strategies must be placed firmly within the context of an overall appropriation strategy.

[37] See the European Commission's proposed initiatives to support patenting, particularly by SMEs, in the Green Paper on Innovation and the First Action Plan for Innovation in Europe.

### III.3 3 Evidence

There is a large theoretical literature on patents which elucidates comprehensively the trade-offs between incentives and disclosure. For policy purposes, however, empirical evidence is needed to know how to make those trade-offs in practice. Recent survey research has provided a body of data on patents that sheds some light. With these data we can address four questions that currently concern European policy makers:

- Do European firms patent less than their American and Japanese competitors?
- What is the value of patents and design protection relative to other means of appropriation?
- How important are patents as an incentive to innovate?
- How important are patent databases as an information source?

### III.3.4 Do European Firms Patent Less?

The answer to this question is affected by several things. First, European firms may patent less simply because they invent less. But the concern, which gives rise to this question, has to do with European firms' ability to commercialise and capture value from their innovations. Thus we look at patent rates: of all patentable innovations, how many are indeed patented? Second, different industries have different patenting patterns. It is estimated that industry average patent rates range from 15% in base metals and steel to 74% in pharmaceuticals.[38] So any difference in countries' patenting rates could arise simply from differences in industry structure.[39] Combining the data from several surveys, and making corrections for differences in industry structure, we can present Table III.3.[40]

**Table III.3 Standardised patent propensity rates for large European and American firms**

| | Product innovations | Process innovations |
|---|---|---|
| Europe | 44% | 26% |
| United States | 52% | 44% |

Notes: Based on a standardised industrial distribution and weighted by R&D expenditures.

[38] Arundel and Kabla (1998)

[39] This is known in its general form as Fischer's Paradox: a country could have higher patenting rates in every industry, yet have a lower national patenting rate (by being heavily specialised in heavy metals for example).

[40] The data are from the 1993 PACE survey and a similar survey conducted in the United States. The American survey is referred to as the Carnegie Mellon Survey (CMS). The results presented here are based on Cohen *et al.* (1998a,b).

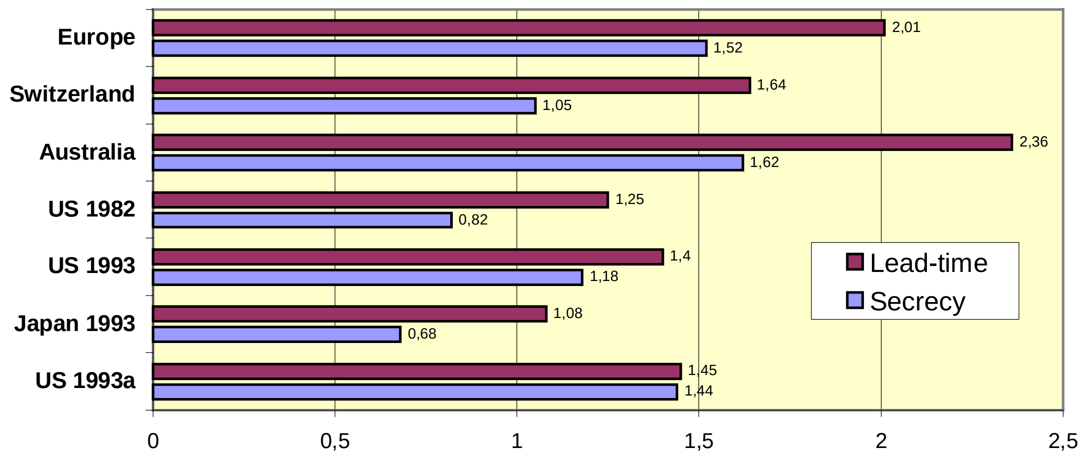
Because the surveys from which these data are drawn were not identical, some manipulation was needed to generate comparable averages. Therefore, the estimated patent propensity rates are unlikely to be highly accurate. However, on a qualitative basis, the results indicate that European firms probably do patent less than American firms.

### III.3.5 Patents and Appropriation

One of the goals of the patent system was to make it possible for firms to appropriate the benefits of their innovative activity. But, contrary to assumptions made in much of the literature on the subject, patents are not the only possible means of appropriation. Indeed, survey research has consistently shown, since 1987, that patents are less important than many other appropriation methods, outside a few sectors such as pharmaceuticals.

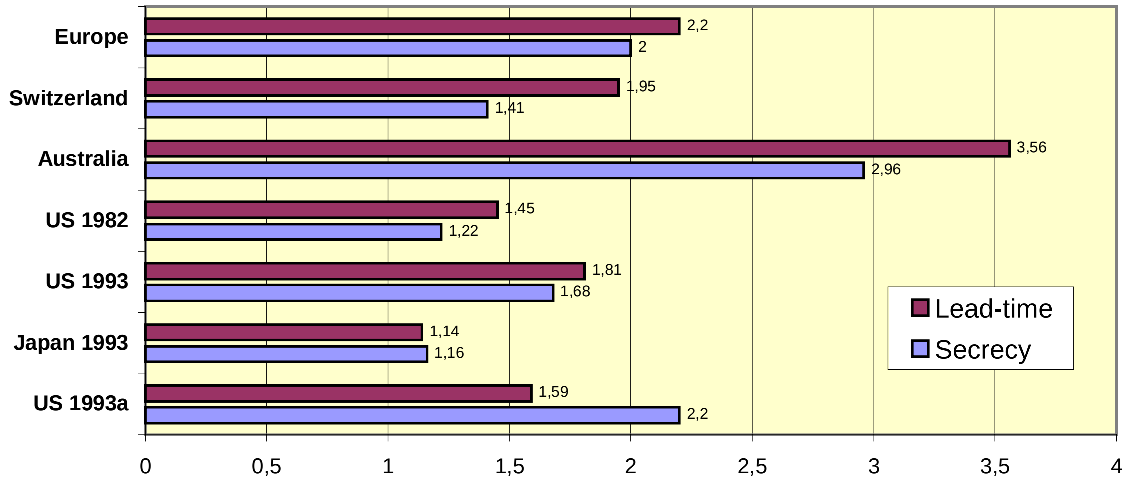
Many methods for appropriation exist, for example: secrecy, lead time, after sales service, design registration and frequent technical improvements. Innovation surveys in several countries have focused on secrecy and lead times, and a comparison across five regions can be made regarding those two methods. Figures III.10 and III.11 show how secrecy and lead times compare to patenting as a means of creating or preserving competitive advantage from innovation. A value of 1.0 indicates that the method is of equal importance as patenting.

**Figure III.10 Relative importance of secrecy and lead-time for earning competitive advantages from PRODUCT innovation**




Sources: *Europe: 1993* Community Innovation Survey (Arundel, 1996); 5,147 innovative firms in Norway, Belgium, the Netherlands, Luxembourg, Ireland, Denmark, and Germany. The measurement scale is the percentage of firms that report that each appropriation method is 'moderately important' or higher on a five-point scale. *Switzerland*: Harabi (1995); 358 innovative firms. The measurement scale is the mean for a seven-point importance scale. *Australia*: McLennan (1995); 1,960 innovative firms. The measurement scale is the percentage of firms that report that each appropriation method is 'moderately important' or higher on a five-point scale plus an option of 'method not used'. *US in 1982*: Levin *et al*. (1987); 650 R&D performing firms. The measurement scale is the importance of each method in the firm's 'line of business' using a seven-point scale. *US in 1993*: Rausch (1995); 236 innovative firms. The measurement scale is the percentage of firms that report that each appropriation method is 'moderately important' or higher on a five-point scale. *US in 1993a and Japan*: Cohen *et al. (1998a):* 623 US firms and 497 Japanese firms, standardised to the same industrial distributions so that the results are directly comparable. The measurement scale is the average percentage of innovations for which the mechanism is considered effective.

**Figure III.11 Relative importance of secrecy and lead-time for earning competitive advantages from PROCESS innovation**




The results show that the average importance of secrecy and lead time advantages is consistently *higher* than the importance of patents, with the exceptions of the 1982 survey in the US and the 1993 survey in Japan, where secrecy was less important than patents for product innovation.

The 1993 results for the US and Japan are based on an identical measurement scale and the results are standardised to an identical industrial distribution. We can conclude, therefore, that American firms find both lead time advantages and secrecy to be of greater importance, relative to patents, than Japanese firms. In contrast, there is very little difference in the absolute value of patents for Japanese and American firms (results not shown). On average, patents are effective in protecting the competitive advantages of 38% of Japanese innovations and of 36% of American innovations.[41]

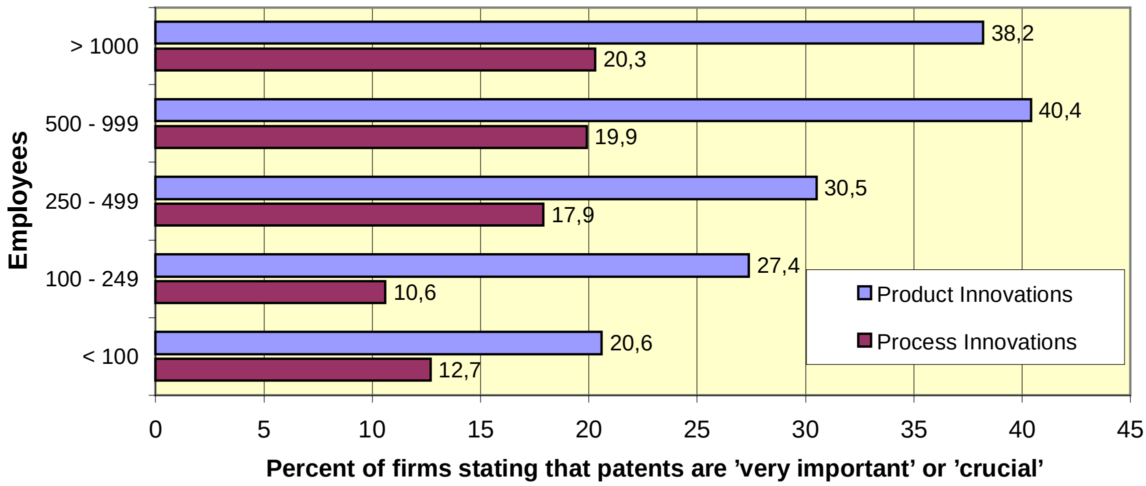
A comparison of the US results for 1982 and 1993 also suggests that the relative importance of secrecy versus patents has increased, although an unknown part of this difference could be due to differences in the US industrial distribution over time or to sampling variation. Nevertheless, this result suggests that the increase in the number of patent applications in the US since 1982 has *not* been due to an increase in the *relative* value of patents compared to secrecy.[42] This conflicts with the common assumption that patents and secrecy are mutually exclusive methods for preventing competitors from copying an innovation. There are two possible explanations: they are not mutually exclusive or firms have other reasons for patenting. Both of these explanations are discussed below.

[41] Cohen *et al.* (1998a).
[42] Kortnum and Lerner (1997).

### III.3.6 Factors Influencing the Importance of Patents

In addition to large differences in the importance of patents by sector mentioned above, several other characteristics influence the importance of patents to firms as an appropriation method. Figure III.12 gives the 1993 Community Innovation Survey results for seven European countries for the importance of patents by firm size for both product and process innovations. 38.2% of innovative firms with over 1000 employees state that patents are 'very important' or 'crucial' to their ability to maintain competitive advantages from their product innovations, compared to 20.6% of firms with fewer than 100 employees. The effect of firm size is partly due to larger firms having in-house patent offices, which means that they tend to patent routinely, as long as the expected value of the patent does not outweigh the costs of disclosing information.[43] There is one very important group of exceptions, small firms that do find patents or other IPRs to be a crucial part of their business strategy. These firms tend to be in high technology areas such as biotechnology or software where IPRs are essential to attracting venture capital. One issue becomes how to facilitate the participation of SMEs in the intellectual property activities.

**Figure III.12 Importance of patents for competitive advantage by firm size**




Source: CIS survey (Arundel, 1996; Arundel 1997). Results are for 5,147 innovative firms and are weighted to reflect the distribution of firms across sectors, firm size classes, and country.

The importance of patents is also greater among firms that perform R&D. 26.6% of R&D performers find product patents to be very important or crucial, compared to 18.2% of non R&D-performers. Similarly, 15.5% of R&D performing firms versus 8.3% of non R&D performing firms find process patents to be of importance to competitive advantage. Patents are also more important to firms that export to the United States or Japan, suggesting that patents play an important role in the ability of firms to enter foreign markets.

The European Commission's Green Paper on Innovation cites application and defence costs as important barriers that prevent firms from patenting their innovations. These costs – particularly defence costs – could be of importance for SMEs.[44] However, for large firms, the

[43] Arundel and Kabla (1998).

[44] A survey of innovative Dutch SMEs in five high technology sectors supports the greater importance of application and defence costs as a reason not to patent for smaller firms (Arundel *et al.*, 1997). The cost of a

PACE results show that limits to the effectiveness of patents in preventing imitation and the disclosure of information are considerably more important reasons not to patent. These latter two reasons are cited by approximately 60% of PACE respondents that decided not to patent an innovation, compared to 26% who cited application costs and 13% who cited defence costs.[45]

Econometric analyses of the factors that influence the patent propensity rate found that application and defence costs had no effect, after controlling for the influence of firm size, sector, and the importance of patents to prevent copying. The most important brake on patenting was the ease of imitation, followed by information disclosure.[46]

It is important to note that the recent EPO decision to reduce application costs is unlikely to have a significant impact on the percentage of innovations that are patented. This is because the greatest effect of lower application costs will be on marginal innovations, for which the expected financial benefits of a patent are approximately the same as the application costs. Furthermore, interviews with Dutch SMEs showed that the specific costs of the patent application, *per se*, were of less concern than the additional costs of employing a patent attorney and the time spent by staff on preparing the application.

### III.3.7 Patents as an Incentive to Innovate

The patent system exists in part to solve the appropriation problem, and to the extent that it does alleviate this problem, the ability to patent should provide incentives for firms to innovate. Surprisingly, there has been little empirical research on this question. We can cite two studies. Edwin Mansfield sampled 100 R&D managers about the percentage of their firm's innovations that would not have been developed without patent protection.[47] The answers were surprisingly low, with two exceptions. In chemicals and pharmaceuticals 38% and 60% of innovations would not have been undertaken had patent protection not been available. In most other sectors, though, patent protection provided less incentive.[48] These results must be treated with caution because of the very hypothetical nature of the question. "What if..." questions are notoriously difficult to answer.

If patents provide positive incentives, one of the effects of patenting an innovation is likely to be that competitors find it difficult to imitate the invention. That is, while imitation is probably not prevented entirely, it should be delayed by the presence of a patent. The innovation surveys in Japan and the US attempt to establish the magnitude of this effect of patenting. Table III.4 presents the results of these surveys.[49]

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patent application was the most frequently cited reason (40% of firms), followed by ease of circumvention (35%), information disclosure (34%), and defence costs (27%).

[45] Arundel and Kabla, forthcoming

[46] Arundel and Kabla, forthcoming

[47] Mansfield (1986).

[48] Absence of the ability to patent would have resulted in 17% fewer inventions in machinery, 12% fewer in fabricated metals, 11% fewer in electrical equipment, and would have had no effect in office equipment, motor vehicles, rubber, and textiles.

[49] Unfortunately the PACE survey, while asking about imitation lags, does not distinguish between patented and non-patented innovations. Lag times are consistent for European firms though: the average imitation lag for all innovations is 34 months.

**Table III.4 Mean imitation lags in months for the firm's most significant product and process innovations**

| | Japan | | United States | |
|---|---|---|---|---|
| | **Unpatented** | **Patented** | **Unpatented** | **Patented** |
| **Products** | 24 | 31 (30%) | 34 | 44 (29%) |
| **Processes** | 24 | 41 (71%) | 41 | 50 (22%) |

Table III.4 shows that patents do indeed provide protection against imitation, and thus provide incentives to innovate. Patenting increases lag times by roughly 30%, which in some industries may represent a significant increase in the economic value of an innovation. The survey question refers to "significant" patents so it is likely that a firm can recoup more than the cost of the patent during the additional months of effective protection from imitation. We should note, though, that even unprotected innovations are not imitated immediately. An imitation time lag between 24 and 41 months is observed. This implies that patents are not the only appropriation method, and thus not the only source of incentives to innovate. This is consistent with the discussion of secrecy above.

### III.3.8 Strategic Reasons to Patent

The traditional, and most important reason for European, American, and Japanese firms to patent is to prevent copying. The ability of patents to prevent copying is what creates imitation lags and the possibility of earning monopoly profits. But firms also patent for strategic reasons, including to block competitors from applying for a patent, to reduce their risk of being sued for infringement, and to use in cross-licensing negotiations with other firms. A contemporary example of patents being used in this way concerns colour correction technology, used in many colour reproduction devices such as photocopiers. In the mid 1980s a firm acquired a patent on the use of look-up tables using standardised colour descriptions in colour correction software. This is a very broad patent, and as such effectively gives control of colour correction development to its owner. Virtually all large firms in the field have licenses, but one suspects that this patent, and the licensing strategy of its owner is a very large barrier to entry for small and medium-sized firms.

The PACE survey in Europe and the CMS surveys in the US and Japan provide evidence of the importance of these strategic reasons. The results show that preventing copying and patent blocking are more important reasons to patent for US firms than for European and Japanese firms. By contrast, the use of patents as a means of sharing information, for example through licensing or in negotiations, is less important for American firms than for European and Japanese firms. Cohen *et al*'s analysis of the results for the United States and

Japan led them to conclude that strategic motives for patenting such as blocking, could be leading to excessive patent rates that increase costs to both private firms and to the public.[50]

### III.3.9 Patents as a Tool for Disclosure of Information

The patent system creates incentives to innovate by giving inventors a form of monopoly power. It was no secret that patenting could seriously reduce the distribution of information. Acknowledging that innovation and learning are cumulative processes, policy makers have tried to create a patent system that alleviates this negative effect. Thus, the system is designed so that a patent is in fact a tool for information dissemination. This is the rationale for making patent documents public information. Any firm interested in R&D on a particular subject can look at the patent databases to see what has been patented.

David and Foray (1994a) suggest strengthening the public disclosure aspect of the patent system so that patents act as a clearing house for new knowledge.[51] This would require encouraging firms to patent a much higher percentage of their innovations than they patent today in addition to improving disclosure of existing patents. The latter would require 1) the disclosure of complementary information that is necessary to replicate the invention and 2) improving public access to patent databases. Neither of these is automatic, and research shows that the patent archives are under-used as a source of information. This indicates a useful point of policy intervention, but to address the policy issue we must first enquire about the current use of patent databases as sources of information. The most telling question is "Who uses patent databases?"

The European Community Innovation Survey asked respondents from innovative firms about the importance of eleven external information sources for their firm's innovation activities during 1990 to 1992. One of these sources is 'patent disclosures'. The raw data are striking. SMEs, defined as firms with 10 to 499 employees, find patents to be the second least important sources of information; only consultants are less used. Only 6% of non-R&D-performing SMEs and 18% of R&D-performing SMEs find patent disclosures to be important information sources. In contrast, over 50% of both types of SMEs find trade fairs, suppliers, and customers to be an important information source.[52] It is large R&D performing firms that use patent disclosure as an information source: 34% state that they find it of value.

The raw data may be misleading, as use of patent disclosure could be affected by industry-specific factors or a firm's propensity to patent, to name but two possible confounding factors. Econometric analyses, which take these effects into account, produce robust results. Firm size, whether or not a firm performs R&D, propensity to patent (which could be a proxy for the use of patents as an appropriation method), and the firm's sector all have a significant

[50] Cohen *et al.* (1998a).

[51] This argument is relevant for process innovations, but it is much weaker for product innovations because firms can reverse engineer their competitors products once they are on the market. (In fact, the PACE survey shows that reverse engineering is one of the most important information sources used by firms). The argument is strengthened, however, if we assume that there is a lot of tacit knowledge in innovation that is not transmitted by the patent. Although tacit knowledge has been receiving a lot of attention lately, we are not aware of any empirical research that has attempted to measure it and determine its role in innovation.

[52] The relative importance of patent disclosures compared to other information sources is robust and changes very little when based on the means.

impact on the importance attributed to patent disclosures as an information source.[53] A striking result is that if a firm is in a sector that has a high propensity to patent, it is more likely to use patent databases as information sources. The obvious interpretation of this result is that a necessary condition for a firm to use patent disclosure as an information source is that it believes there to be useful information in the database.[54]

This suggests that an increase in patenting will provoke an increase in use of patent databases, which would be good for information diffusion. The problem is not so easy, however. The analyses by Arundel and Kabla point to concerns over disclosure as the major reason not to patent.[55] In order to encourage firms to patent more, something would have to be offered in return, such as broader patents that would reduce the ability of competitors to 'invent around'. This could have the contradictory effect of *reducing* the amount of information freely available in the public knowledge pool. The end result could be more publicly available knowledge, but greater restrictions on its use.

The earlier discussion noted that the patent system was designed to give firms an incentive to innovate while encouraging the diffusion of knowledge. The data presented here show that the incentive aspect of the patent system is better developed, in the sense of being more effective, than is the diffusion aspect. Innovators, naturally, will be more vocal regarding the importance of the former than of the latter as it has larger and more certain effects on private welfare. But social welfare derives at least as much from the diffusion of knowledge. Indeed, some suggest that there has been an excessive emphasis on knowledge creation to the exclusion of attention to knowledge diffusion, and that we may have a suboptimal amount of the latter.

### III.3.10 Policy Considerations

What are the appropriate policy responses? Clearly, there is no short-term public benefit in increasing patent protection if non-patent incentives to invest in innovation are adequate. Patents can create monopolies and interfere with the diffusion of new inventions. The latter is of particular concern in respect to enabling technologies, although there is very little evidence, outside of the biotechnology sector, that patents have interfered with technology diffusion.[56] At the same time, the comparison between European and American patent propensity rates in the early 1990s, which is the most recent data available, indicates that European firms are lagging behind their American competitors in their propensity to patent. Their American competitors also appear to be using patents more aggressively in ways that could be destructive both to the public interest and to the self-interest of the firms. The use of patents to block competitors interferes with the use of information, while patenting to prevent an infringement suit is a waste of the firm's resources if the firm can obtain the same end by publishing the details in trade or scientific journals.[57]

[53] Arundel & Steinmueller (1998).
[54] See David and Foray (1994a).
[55] Arundel & Kabla, forthcoming
[56] A 1998 survey by Statistics Canada asked biotechnology firms if they had had to abandon an important research project because progress was blocked by patents held by other firms. 15% responded yes.
[57] The real motivation here may be to maintain secrecy as long as possible while simultaneously preventing future infringement suits.

Over the short term, European firms could have little choice but to play the same non-cooperative strategic game as their American competitors. However, the medium and long-term policy goal should be to discourage such misuses of the patent system. This cannot be done by strengthening patents, in the sense of making them easier to obtain. For instance, introducing patent protection for software may provide firms with a weapon to stifle competition. Thus any introduction of property rights in this area must be done with clear rules on compulsory licenses, and other means of circumventing the tendency of patents to prevent innovation.

In fact, a good argument can be made for weakening patents and for making it more difficult to obtain them. This could be achieved by limiting patent width for new technologies in order to reduce the ability of patents to block competitors from using and further developing enabling technologies. In the same line, it may be worth increasing the level of the inventive step to prevent nuisance patents.

In return for limiting patents, a better system for resolving patent infringement cases would be worthwhile. In particular, the system should be designed so that large firms do not have a distinct advantage over small firms. This would provide a better incentive for small firms to invest in innovation.

Policy to increase the patenting activity of SMEs has reduced patent fees. Fees, however, are a small proportion of the costs of obtaining a patent. Preparation time and legal expenses make up the lion's share of costs. Thus streamlining the procedure to make it simpler would be more effective. To this end European harmonisation would reduce dramatically costs of firms that need multi-country protection.

What advice can be given in response to European policy documents that suggest introducing educational programmes to promote patents, particularly to SMEs? Are patents the only available prescription to improve competitiveness? The answer, based on the empirical evidence on appropriation methods, is clearly no. IPR strategies must be placed firmly within the context of an overall *appropriation* strategy. The danger of policies to emphasise the value of patents is that they could cause firms to neglect other factors that are essential to the ability to profit from innovation: secrecy, building lead-time advantages, and other methods such as frequent technical improvements. Educational materials aimed at SMEs need to carefully delineate the conditions where patents are of value and where they are unlikely to offer substantial advantages. A similar argument is made in a recent ETAN report on patent policy.[58]

## Patent disclosures

There are two general policy options to improve the value of patent databases to SMEs. The first is to improve the value of the information held in patent databases and the second is to improve access.

The value of patent databases can be increased by improving the quantity and quality of the technical information. The quantity can be increased through policies to encourage firms to patent a higher percentage of their inventions, as suggested by David and Foray (1994a). This

[58] ETAN (1999). See Section 4 of the Executive Summary.

is already under consideration in many countries as a means of improving the competitiveness of SMEs by strengthening their use of intellectual property.[59]

Policies to increase the quality and quantity of the information available in patent databases, and to encourage their use, confront several difficulties. One is that higher patent propensity rates could limit the diffusion of innovations to SMEs by reducing the pool of technologies that can be adopted without paying license fees. It could also interfere with the use of technologies that are developed independently by different firms. A more thorny problem is due to the fact that the major barrier to patenting is the disclosure requirement, so it is not clear how more patenting could be encouraged. Reducing patent application fees, for example, is only likely to have a small effect on patent propensity rates because these costs largely discourage the patenting of marginal inventions or patenting by very small firms.

The greatest room for policy action is to help SMEs access patent data. The most effective policy option is to reduce the relative cost of using patent databases compared to alternative information sources. The EPO is moving, fortunately, in this direction by establishing a free Internet site for its patent database.

[59] The quality of the technical information contained in patent databases could be improved through strengthening the disclosure requirement. Another variant, suggested by Bloch and Markowitz (1996), is to introduce a policy of mandatory disclosure of basic inventions that produce a large number of downstream discoveries, although it is difficult to imagine how such a policy could be implemented, since the value of a 'basic' invention only becomes evident over time.

# CHAPTER IV. TYING THE KNOTS: CONCLUSIONS, PRIORITIES AND POLICY CONSIDERATIONS

The transition towards a knowledge-driven economy has many implications for how, and under which circumstances, the process of innovation will thrive. To analyse what this transition means for innovation, we have taken as the point of departure the systemic view of innovation and technical change, as developed in the Maastricht Memorandum. The system model assumes that the knowledge generation inherent in innovation takes place in many more places than just the R&D laboratory. Further, the many different knowledge generation and use activities are linked to each other in a dense network of connections between activities, institutions and agents. Following in part from the Maastricht Memorandum, the systems concept has been developed since the early 1990s, and more and more emphasis has been put on the nature of the links between the different “institutions” as the glue that holds the system together. These links operate through knowledge flows. As a consequence, researchers now emphasise the centrality of knowledge in the innovative process, and in the innovation performance of an economy. This model, with its emphasis on variety in institutions and types of knowledge, and its emphasis on the importance of knowledge flows and the links between knowledge agents, still provides a coherent and informative representation of how innovation and technical change occur.

In chapter I, we have argued that although economies have always been to some extent knowledge-based, some elements have come more explicitly to the foreground or have fundamentally changed in recent years. They justify the claim that we now have moved to a knowledge-based, or more accurately, knowledge-driven society:

- Knowledge is increasingly considered to be a commodity
- New ICTs lower the costs of many knowledge activities
- The degree of connectivity among knowledge agents has tremendously increased

## IV.1 Impact of the Knowledge Economy on Innovation

The review and discussion in chapters I and II have signalled the following impacts of the knowledge-driveness of today’s economies on our view of innovation within the framework provided by the systems model.

Improved understanding of the nature of knowledge, and in particular of the interactions between tacit and codified knowledge have changed our views regarding the diffusion of it. Indeed, emphasis on the importance of tacit knowledge contains the view that an important way in which successful and unsuccessful innovation systems differ from each other is in their distribution power, that is, in their abilities to diffuse knowledge to those who need it. This discussion also underlined the importance of humans as holders and carriers of that knowledge. The renewed interest in innovation clustering is closely related to issues of diffusion, since it is difficulties in diffusion of certain types of knowledge that give clustering its impetus. An effect of clustering is that the centrality of humans as knowledge assets becomes a systemic advantage rather than a disadvantage, and further, creates synergies between actors in all stages of the value chain, and thus facilitates some forms of learning without research. Similarly, the new micro-economic models of knowledge use and transmission rest on more detailed exposition of transmission mechanisms, and again the ability of human agents to absorb the knowledge they receive. Closer examination of the multiple sources of knowledge creation has revealed that the knowledge bases on which innovating firms rest their activities have become broader and more complex. Further, the view of innovation as recombination indicates that variety in diffusion of and access to knowledge must be seen as vital, and learning without research is an idea that must be treated as central to the innovation process. Finally, the rise of the knowledge- or science-based firm has created issues in measurement of economic assets, and again has called attention to the importance of humans, this time coldly as economic assets, in the knowledge-driven economy. From this discussion (elaborated in Chapter II), four main themes can be distilled:

- Diffusion of knowledge throughout the system of innovation is a key element of innovation and technical change
- Innovation without research deserves attention as an important source of technical advance
- The complexity of the knowledge base has increased, for all firms, in all industries and in particular in the service sectors
- Humans are central as holders of (vital) knowledge assets

## IV.2 Policy Implications

These four themes translate to four key areas for policy intervention.

### ICT exploitation

Diffusion of codified knowledge is naturally suited to extension and improvement through use of advanced ICTs. Improved ICT infrastructure will facilitate more rapid and broader diffusion. From the point of view of the "sender" of information, it is very inexpensive to make information available through the World Wide Web. Any knowledge that its holder wishes to diffuse can be made available to anyone with access to the Internet. On the other side, the ability of a knowledge user to find, and acquire (at least in its most simple sense) a wide variety of information is similarly enhanced. Speed and scope have risen dramatically and could be improved yet more with investments in ICT infrastructure. The importance of ICTs is made even more apparent by considering complexity in the knowledge base. Increases in complexity imply that innovating firms will more and more have to look outside their own competences to find the knowledge they need to develop next generation products. This must be done rapidly and inexpensively. Again ICTs can make this possible. In a different way, our appreciation of innovation without research lends importance to ICT exploitation. To make innovation without research valuable, different parts of the innovation, production and consumption systems must be linked. They must be linked, though, not only through agents in each sphere deliberately passing messages, but also through the collection of information and data from production or consumption for example, and using that data, in real time in many cases, to affect design and product development. This demands new ways of gathering the data, and passing it without human intervention between different spheres. Again ICT is paramount.

## Mobility and training

Repeatedly, and from more than one source, we have seen the importance of humans as knowledge assets — holders and carriers of knowledge. The importance of tacit and specialised knowledge implies that timely transmission of some important knowledge can only be achieved by the movement of the individuals holding that knowledge. Mobility, and schemes to enhance it become important. Similarly, training is important. Efforts to increase mobility of knowledge workers, for example through a transferable pension and social benefits scheme, or the creation of a virtual European College will address the problem in the short and medium runs. However, it will not address a chronic labour shortage. A common complaint made by firms with regard to adopting high tech innovations (and particularly IT innovations) is the shortage of labour with the skills necessary to implement the innovation. There are two types of shortages: those within the firm, which, given a more general shortage can be addressed by continuous training within the firm; and a more general shortage of European labour trained in new technologies. The latter can only be addressed at the university, or more generally, post-secondary education level.

## Innovation finance

In this report, we have examined the problem of innovation financing, in light of the transformation towards a knowledge-driven economy. We have argued that the rise of the knowledge-based firm (partly induced by the rise in knowledge-based service industries) is accompanied by increasing problems in assessing the potential economic value of these (start-up) firms, from an investor's perspective.

This is partly caused by the lack of expertise from the side of the potential investor in assessing "the intangibles and what is in the head (the idea, his tacit knowledge) of the (would-be) entrepreneur". The problem lies also in the communication skills of most (potential) entrepreneurs, often with a technical background and not able to write a proper business plan. The result is a situation in which venture capitalists and banks might claim that there are no well-formulated innovative ideas to invest in, whereas on the other hand entrepreneurs feel misunderstood in that investors can't properly assess the value of their ideas. Hence, an important source of the mismatch between supply of and demand for venture capital.

In essence, this calls for better methods to assess the (potential) market value of intangible assets. Assessing their economic value has received more attention recently, both in business (as witnessed by the increasing attempts of accounting firms to develop more standard routines to capture the value of intangibles/knowledge) and in academic research.[1] An interesting initiative in this respect is, for instance, the development of the MERITUM model

[1] See for instance, Canibano *et al*. (1998, 1999a, 1999b).

to measure and disclose information on intangibles, mainly based on the best practices of a selected group of European companies. [2] This model uses three categories of intangibles, namely human capital (knowledge and skills, which people take with them when leaving a firm), structural capital (knowledge, which stays in the firm when people leave: IPR, know-how, data bases, routines, management procedures), and relational capital (relationships with clients, suppliers, R&D allies).

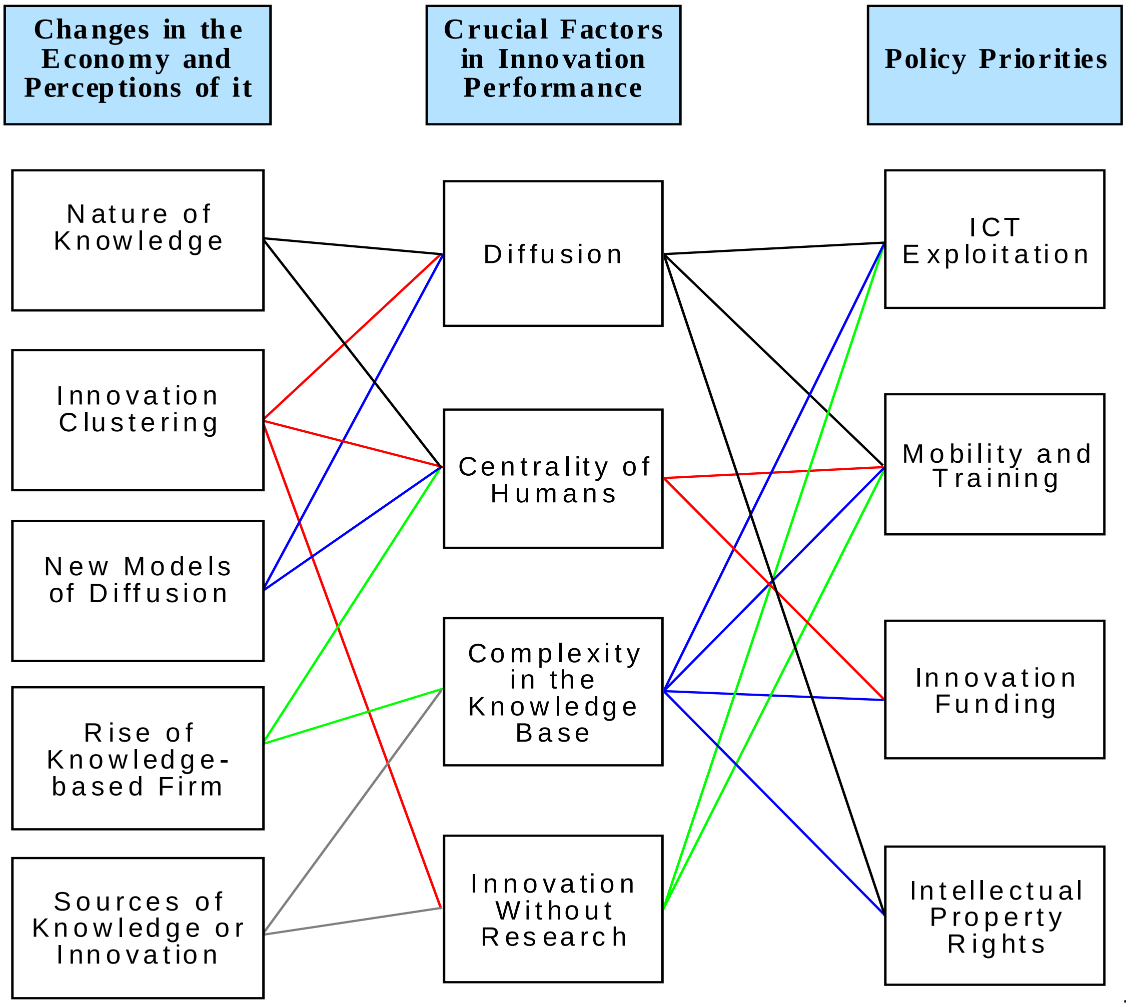
### Intellectual property rights

Intellectual property rights provide incentives for agents to pursue innovative behaviour, creating new knowledge. The property rights systems have been explicitly designed, though, with diffusion of new knowledge as a goal. The idea is that if knowledge is "protected" from theft, there would be no reason not to publish it, and the act of publishing provides future innovators with more knowledge on which to build or with which to create new combinations. Thus the intellectual property rights system is in many ways connected to the ability of a system to distribute knowledge. Similarly, as knowledge bases become more complex, innovators need more diversity in the knowledge they posses, and in the knowledge they can access. Patent databases are one way to provide this access. In principle, patents represent the latest state of the art for applied knowledge. Thus a patent database is, again in principle, the best source for discovering new applied knowledge. The rapidity with which electronic patent databases can be searched could significantly lower the costs for a firm trying to innovate outside its core competences.

This discussion is summarised graphically in Figure IV.1. The left-most column shows the recent changes in our understanding of innovation in the context of the new, knowledge-driven economy. Each of these five features provides argument for more than one of the four central issues in the success of an innovation system. In turn, each of these four pillars of a successful modern innovation system is affected by more than one of the policy themes shown in the right-most column.

[2] MERITUM (MEasuRing Intangibles To Understand and improve innovation Management) is a project financed by the TSER programme. It is co-ordinated by a research group from the Autonomous University of Madrid, directed by Leandro Canibano and Paloma Sánchez. The other partners are institutions from France, Sweden, Norway, Finland and Denmark.

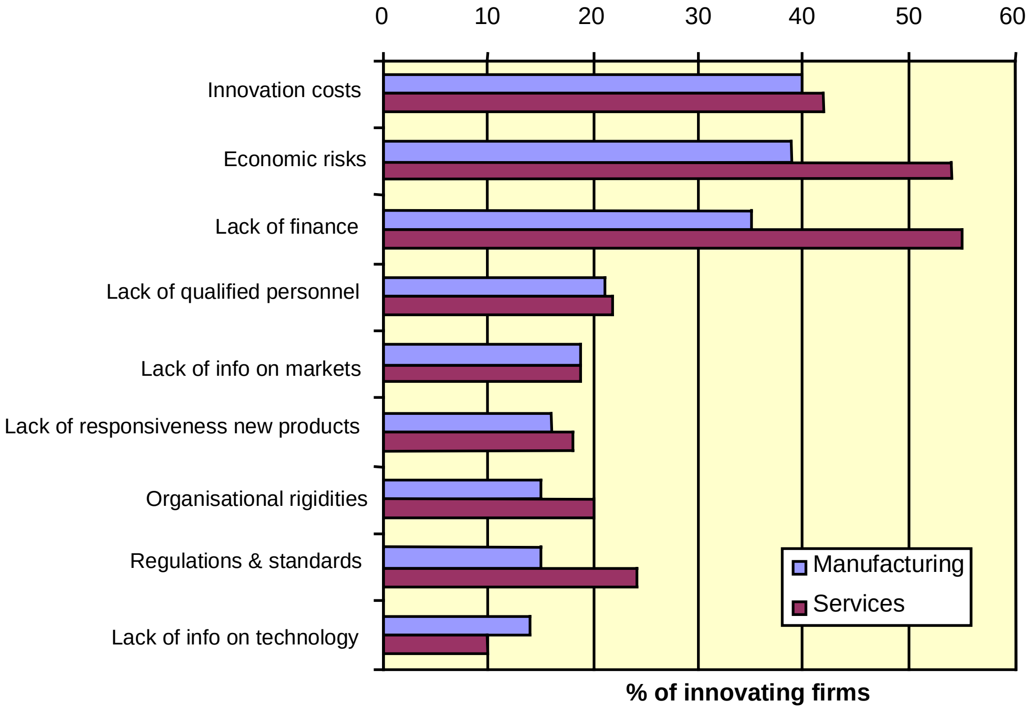
**Figure IV.1 Relations between the knowledge economy, innovation systems and innovation policy**




## IV.3 What Do Firms Say?

The discussion above has originated largely in the academic research done on the economics of innovation. This research has emphasised certain aspects of the innovation process and system as crucial to its performance, and from these, acknowledging new opportunities (and problems) created by the knowledge economy, we deduce policy-theme consequences. But empirical data, generated by the Community Innovation Survey, allows us to address the same issue starting at the enterprise level. Firms have experience with innovation, and in particular with innovation projects that are delayed, abandoned, or not even begun. The Community Innovation Survey asked about the causes of each of these innovation "failures". Figure IV.2 shows the proportion of firms, which see various causes for delaying, abandoning or not beginning innovation projects.

**Figure IV.2 Hampering factors for innovation projects not even started**




Source: CIS II

The three most common causes of innovation set-backs: excessive perceived economic risks; high innovation costs; and lack of appropriate sources of funds; all pertain to the financing of innovation. From the perspective of potential innovating enterprises, there seems to be a mis-match between the demand for funds to invest in innovation and the supply of them. The aspect of riskiness speaks to issues in the venture or risk capital market. The perceived high cost of innovation is in part due to demand for funds exceeding their supply. The lack of appropriate sources of finance raises the same issues. Financial issues are obviously at work here, but they are not the only ones. Risks can be lowered by collaboration among enterprises, and more generally, networking among them. Costs can be lowered by having better, more highly-skilled labour, and more generally, a thicker market for the highly-skilled. The latter issue — the availability of skilled labour — arises directly from the fifth cause of innovation set-backs, namely the lack of qualified personnel. Organisational rigidities can also be addressed by having differently trained personnel. Studies of engineers show that the broader the education, the more flexible the worker in transferring from job to job, and, it would follow, from technology to technology. Lack of information of various kinds raises the issue of knowledge diffusion. Can knowledge be codified in such a way that the new ICTs can be used to present the needed knowledge in an easily and rapidly accessible form? Finally, fulfilling regulations and standards can be seen as a cost of innovating, and thus really a sub-category of the first answer. Nonetheless, identifying it separately indicates that one route to lowering the costs of innovation is through harmonisation, within Europe, of regulations and standards. This discussion is summarised in Table IV.1.

**Table IV. 1. Linking Problems and Policy Themes**

| Problems experienced by European firms (in order of importance) | Innovation policy theme |
|---|---|
| Excessive perceived economic risks | -Financing of innovation<br>-Networking |
| Innovation costs too high | -Financing of innovation<br>-Networking<br>-ICT, codification of knowledge, mobility |
| Lack of appropriate sources of finance | -Financing of innovation |
| Organisational rigidities | -Training |
| Lack of qualified personnel | -Training and mobility, education |
| Lack of information on technology | -Codification of knowledge<br>-ICT |
| Lack of information on markets | -ICT (also government as sophisticated user) |
| Fulfilling regulations and standards | -Harmonisation |

## IV.4 Policy Priorities

The concerns expressed by firms co-ordinate well with the new insights garnered from economics research. To a great extent, the policy themes or priorities that emerge can be seen as addressing the costs of "non-Europe". Historically, the European project has focussed attention on economies of scale, that is, on lowering costs of production, and rationalising duplication. The future thrust of the European project must be on taking advantage of the European dimension. Thus policy aimed at alleviating the non-European aspects of the innovation system, and attempting to create a single system, rather than multiple loosely co-ordinated national systems, will take advantage, now, of the scope in Europe. We can summarise then, four policy themes or priorities that emerge from the historical project, academic research, and from the concerns of enterprises themselves.

- **ICT exploitation**. Advantage should be taken by European firms and institutes to exploit the possibilities and chances that ICTs offer. These ICTs enable increased inter-connectivity between knowledge agents through (virtual) networking.

- **Knowledge Mobility and Training** The importance of tacit and specialised knowledge calls for greater mobility of knowledge workers as well as investment in training (both public, which is the "domain" of educational systems, as well as private, which is the domain and responsibility of firms)

- **Intellectual Property Rights** (patents, copyrights, design registration) can be important instruments to codify and commodify knowledge and hence, the diffusion of knowledge. Their dissemination and use should be further stimulated, while keeping in mind the limitations of IPRs as a dissemination mechanism.

- **Funding conditions** (financial and fiscal) should be geared to more innovative risk taking and better rewards thereof.

## IV.5 European Innovation Policy Making: Filters, Constraints and Scope

In this report we have discussed the scope of innovation policy and its relationship to other policy areas. The systems view of innovation forces one to take a very wide perspective on innovation. There is a risk, however, that in doing so one enlarges the issue so much that innovation policy becomes too pervasive. All policy actions would in the end have an affect on innovation and could therefore be considered as part of innovation policy. There is a need to define the limits of innovation policy. We restrict attention, therefore, to **policy** actions, which aim to raise **the quantity and efficiency** of **innovative** activities at the European Union level, which affect *directly* the development and diffusion of new products, processes and services. It follows from this definition that, for the sake of simplification and rationalisation, the concept of "European innovation policy" should be confined to the actions undertaken by the supranational institutions of the European Union. Hence, this is a narrow definition of innovation policy, which also explicitly takes into account the principles of subsidiarity and additionality.

However the tighter the limits, the more important to know the relationships between the elements of innovation policy and the elements of other policies, both in terms of policy actions, and in terms of policy goals. Competition policies, for example, have an important effect as competition itself is the main driver of innovation. Technical change in recent decades has destroyed the rationale for state-owned or regulated utility monopolies. The deregulation of these sectors to introduce competition has spurred enormous amounts of innovation. In addition, we must observe that actions of two policies can contradict each other as when, for example, tobacco farmers are subsidised, while cigarettes are taxed and anti-smoking campaigns are waged. But innovation policy, with its goal of increasing efficiency of innovation can also in principle have a negative impact on other goals. Encouraging innovation agglomerations increases efficiency, for example, but may have a deleterious effect on social cohesion, as it can create innovation-rich and innovation-poor regions. A strong effort should therefore be made to detect the way innovation policies interact with other policies and other policy goals. These effects should clearly be used in judging policy, both *ex ante* and *ex post*. Efforts at policy co-ordination can be extremely valuable here, watching out for possible negative (or positive) interactions, in order to initiate timely discussions with other policy-makers. The establishment of a unit (a "watcher") at the European level to detect inconsistencies and contradictions between instruments of different policies with respect to the objectives of innovation policy would probably be worthwhile.

## IV.6 General Policy Considerations

### High tech or low tech?

Typically, in discussions of technical change, innovation and innovation policy, high tech industries take pride of place. There are many industries, which today are identified as high tech: electronics; the information and communication technology industry; biotechnology and pharmaceuticals are some of the most obvious examples. Very often the criterion by which an economy's innovation performance is judged is the strength of these high tech industries. This is understandable, as these industries are often also growing very rapidly, and high growth rates are generally a good thing. We must approach this point of view with caution though, for more than one reason. First, while high growth rates are generally a good thing, high growth rates in a small industry will contribute little to overall growth, whereas moderate growth rates in a large industry will have a bigger effect. Many of the high tech industries are relatively small, so devoting innovation policy resources to those industries may be a mistaken allocation of resources. From the point of view of overall economic growth, the growth rates of large sectors are most important. Since we believe that growth is intimately linked to innovation, innovation in the large sectors is important. But many of the large sectors fall into the low-tech category, according to standard definitions.[3] It is certainly true that there are industries in which significant amounts of innovation and technical change are noticed. Biotech, IT, pharmaceuticals are obvious. But they are far from the only industries in which innovation is important. Innovation policy and programmes must be designed to include the other, less glamorous industries.

- Innovation is important in all industries, from high to low tech. Policy makers must not be seduced by the glamorous industries. When it comes to innovation policy all industries should be targeted.

### European variety

European heterogeneity, so often decried, can in fact be an asset to be exploited. If innovation as recombination is important, then a wide variety of knowledge available to be combined is valuable. Similarly, at a slightly higher level, a wide variety of approaches to problems and problem-solving can also be valuable. Variety can be created and preserved. Creation arises naturally in the research and innovation process. Preservation comes from codification and archiving. But this is not enough; firms need easy access to this variety, and this turns on the distribution power of the innovation system. Maintain variety by supporting the innovation that takes place through demand-side factors, applied research or instrument development. Since variety creation and preservation takes place at the level of particular firms or research institutions, fostering the technological capabilities of firms will go a long way to creating and maintaining diversity.

[3] The OECD definitions, developed in the mid 1980s, and which have become a standard, define high tech as industries spending more than 4% of turnover on R&D; medium tech as industries spending between 1% and 4% of turnover on R&D, and low tech as spending less than 1%.

- European heterogeneity or variety can be exploited through networking of firms and scientists, to create a vibrant learning culture in which many different ideas and approaches are available as inputs to firms' innovation and learning.

## Small and medium-sized enterprises

Many firms, particularly small and medium-sized enterprises in traditional manufacturing and service sectors such as transport and forwarding, as well as trade, often lack the potential to exploit the opportunities offered by new technologies. To a great extent the important bottleneck lies in absorptive capacity: the skills, competence and human capital of the firm is such that it has difficulty making use of knowledge from outside its own area of expertise. Small and medium-sized enterprises could use assistance in getting information from many different places. While competitors and customers are common sources of information, the most reasonable place to consider policy intervention is in the interface between SMEs and public research and learning institutions such as universities. However, heterogeneity among SMEs, both in terms of products and processes and in terms of the sorts of information they need and the skills needed to acquire and use it must be taken into account. The population of information brokering, and technology transfer institutions, which can be encouraged through policy, must reflect the heterogeneity in needs and competences of the SMEs they are designed to help.

- Small and medium-sized enterprises need a variety of institutions, which take into account their heterogeneity, to assist in improving their ability to absorb new knowledge and technology.

## Globalisation and services

Globalisation has been a cause and a consequence of the shift to the knowledge-driven economy. As firms look outside themselves for useful knowledge, they can now, partly because of the new ICTs look globally. This is true both for a search for existing knowledge, and for a search for partners with whom to create new knowledge. The fact that European firms often form alliances with American rather than European firms is often interpreted as a "bad thing". This is not necessarily the case. It turns on whether the alliance brings knowledge to Europe, and whether that knowledge is in turn diffused within Europe. Formation of international alliances to create knowledge can be a very valuable activity, both from the point of view of the private firm, and socially. SMEs have difficulties here, though, and one role for policy in Europe is to facilitate their participation in this activity.

- SME participation in alliances should be encouraged both internationally and with larger firms that typically have experience in this venture.

The service sector continues to grow and become more important in terms of output and in terms of employment. Innovation, as the historical engine of growth, must be fostered within the service sector if the economy as a whole is to continue to grow. Within services, human resources are key to innovation, and the presence of a highly skilled labour force is a strong predictor of future innovation. In addition, ICT plays a central technological role.

## IV.7 Specific Policy Considerations

### ICT exploitation and networking

Diffusion of knowledge and information is an important aspect of a successful innovation system. Today, the diffusion issue is not simply the extent of potential users who use a particular technology. Diffusion continues to refer to the extent and speed of diffusion of a piece of technology, information or knowledge. This is a relatively passive idea. But today diffusion (or distribution) has also an active component: to what extent do knowledge agents, individuals, firms or institutions have access to potentially useful information, knowledge or technology? For both aspects, information and communication technology now play a very important role. The better is the ICT infrastructure, the faster and more extensive will be diffusion, since better ICT reduces costs of it. Codified knowledge can be transmitted very inexpensively, and very quickly to virtually anywhere in Europe. Similarly, with the growth of the World Wide Web, agents are able to search a much bigger "database" for information that might be of use. Demand here is growing in three ways. First, more and more agents are using modern ICT for their knowledge activities. Second, individual agents use the Internet more and more as their main information source, or main entrée in any information search, so the demand for ICT by any individual is increasing. Finally, the scope of uses, and the scope of data transferred continues to grow rapidly. Email and data interchange, two asynchronous transmissions, were the original uses to which the Internet was put. But now we have real-time data transfer, remote instrument control, co-laboratory operation,[4] "streaming" audio and video, web searches, web page creation for diffusing information of all sorts, video conferencing, and so on. Each new use demands more bandwidth. This too creates huge increases in demand for ICT. Europe lags in Internet use, and without serious investments in infrastructure, will continue to do so and will fall further behind, thus creating higher costs for knowledge activities relative to the rest of the world.

Networking activities of a firm can have two effects: they can help the firm find knowledge and information that it cannot generate internally; and it can, when it is part of or generates collaborative projects with other firms, reduce the risks of R&D and innovation. While large firms easily have their own international networks to both sell their know-how and to acquire the know-how from other firms, this is less the case for small and medium-sized enterprises. This group could benefit from increased networking, both to diversify their activities through collaboration, and to monitor international technological developments. A question often raised is whether European programmes to foster collaborations and partnerships should be limited to member countries or should also be open to collaborators from other regions, and most notably the US. The key discriminating point should be associated with learning: it might be in the interest of Europe to involve and fund the participation of selected non-European partners if this provides additional learning potential for European firms.

Finally, networking can be used to address some of the issues surrounding innovation clustering. Creating or encouraging the creation of networks of clusters will soften the competition among regions for glamorous industries. Networks of clusters, focussed

[4] A co-laboratory works through the heavy use of IT and the presence of a small dedicated labour force at the main site, which permit scientists from around the world to share equipment, data and real-time analysis in research fields that require very specific inputs that are either too rare or too costly to be available extensively throughout Europe.

specifically on complementary networks will reduce the minimum critical cluster size, thereby making it feasible for Europe to support a larger number of smaller clusters, in addition to creating new synergies across regions.

- Invest in new technologies and infrastructure to increase European capacity to transmit knowledge that is not easily codified, but which can be transmitted electronically as is done with co-laboratory facilities, such as the US NSF-sponsored Space Physics and Aeronomy Research Collaboratory, in which scientists around the world use joint facilities for scientific collaboration on the upper atmospheric and space sciences, giving them continual access to real-time and archival data. This would permit the growth of European expertise in fields that require very specific inputs that are either too rare or too costly to be available extensively throughout Europe.

- Programmes to encourage networking of firms and centres of excellence within Europe should be expanded to include agents *outside* Europe who can provide Europeans with "knowledge-value-added". SME participation in alliances should be encouraged both internationally and with larger firms that typically have experience in this venture.

- Co-ordinate national telecom infrastructure investments to facilitate European networking to create knowledge sharing among firms through permitting them to undertake joint innovation projects at a distance. One goal is to create a truly European very high speed backbone. This basic infrastructure provides support for virtually all of the activities mentioned here.

## Intellectual property rights

Intellectual property rights are often seen as part and parcel of the commodification of knowledge. To be a commodity, a thing must have well-defined ownership properties, and patents and copyrights go some way to establishing them. In historical terms, the system of intellectual property rights has been established to perform two functions: to create incentives for innovative behaviour, and to help diffuse new knowledge. Past policy measures have emphasised the former objective, and current measures, partly in response to pressures of commodification, have furthered this aspect of IPRs. It is possible to over-emphasise this however, and this may now have happened. Emphasis must be re-established on the distribution aspect of property rights. European firms patent less than their rivals in the US. To encourage patenting, harmonisation at the European level would be desirable. One should take care, however, of the ratchet effect: harmonisation tends to move to the most stringent version of the things being harmonised, and this may move the system in general in the wrong direction. Harmonisation is a step towards strengthening the *European* patent. Similarly, a better system for resolving patent infringement cases would be worthwhile. In particular, the system should be designed so that large firms do not have a distinct advantage over small firms. This would provide a better incentive for small firms to invest in innovation.

Past policy initiatives have responded to the observation that SMEs patent relatively few of their innovations. To increase the patenting activity of SMEs, policy has reduced patent fees. Fees, however, are a small proportion of the costs of obtaining a patent; preparation time and legal expenses make up the lion's share of costs. Thus streamlining the procedure to make it simpler would be more effective. To this end European harmonisation would reduce dramatically costs of firms that need multi-country protection. Educational materials aimed at

SMEs need to carefully delineate the conditions where patents are of value and where they are unlikely to offer substantial advantages. A similar argument is made in a recent ETAN report on patent policy.[5]

The value of patent databases as tools for knowledge distribution can be increased by improving the quantity and quality of the technical information. The quantity can be increased through policies to encourage firms to patent a higher percentage of their inventions, as suggested by David and Foray (1994a). This is already under consideration in many countries as a means of improving the competitiveness of SMEs by strengthening their use of intellectual property.[6] The greatest room for policy action is to help SMEs access patent data. The most effective policy option is to reduce the relative cost of using patent databases compared to alternative information sources. The EPO has, fortunately, moved in this direction by establishing an Internet site (esp@cenet) for its patent database.

- The European patent system needs to be harmonised, thereby reducing part of the economic costs of gaining a patent and increasing transparency for enterprises. Therefore, the European patent must continue to be developed.

- The intellectual property rights system must be used as a way to distribute information effectively, especially among small and medium-sized enterprises. This could be achieved by limiting patent width and increasing patent height in order to reduce the ability of patents to block competitors from using and further developing enabling technologies. In the same line, it may be worth increasing the level of the inventive step to prevent nuisance patents. In return for limiting patents, a better system for resolving patent infringement cases would be worthwhile. In particular, the system should be designed so that large firms do not have a distinct advantage over small firms. Any moves to extend patent protection to software must ensure that this does not have anti-competitive, and anti-distribution effects.

### Knowledge mobility and training

Mobility of knowledge is the glue that holds an innovation system together. All of that knowledge originates in humans, and much of it resides in them. While advances in ICTs have improved our ability to codify, store and transmit knowledge, much remains embedded in individuals. Thus knowledge mobility is tightly linked to human mobility. While it is true that knowledge workers are among the most mobile members of the labour force, obstacles still remain: career interruptions, social insurance (non-)transferability, language, re-location costs in general. To alleviate these problems, the creation of a European College should be considered. Such an institution would provide experts with the financial and career infrastructure to move for extended periods of time without these disruptions.

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[5] ETAN (1999). See Section 4 of the Executive Summary.

[6] The quality of the technical information contained in patent databases could be improved through strengthening the disclosure requirement. Another variant, suggested by Bloch and Markowitz (1996), is to introduce a policy of mandatory disclosure of basic inventions that produce a large number of downstream discoveries, although it is difficult to imagine how such a policy could be implemented, since the value of a ‘basic’ invention only becomes evident over time.

There are indications that the staff qualification structure is shifting in favour of the highly qualified. This highlights the role of human capital in the productive process, in particular in the service sector, and underlines the necessity for helping the less well qualified by implementing training schemes and/or changes in the education structure.

Training schemes could enhance the productivity of the lower qualified employees. At present, training schemes tend to benefit mainly the qualified employees, which further polarises the skill structure of the labour force. Expansion of corporate training programs, however, simultaneously calls for improvements in the quality standards of the schemes involved, so that the search for suitable bodies to sponsor training schemes is facilitated both for companies (and here SMEs in particular) and for employees. In any case, an increase of the educational attainment of employees is a key for modern economies to profit from the job engine represented by the knowledge-driven service economy.

- Mobility of knowledge among firms must be facilitated. This could be achieved by stimulating co-operation among firms in their knowledge activities, or by facilitating senior knowledge workers visiting, for a medium term period, other firms, universities, or research institutes. To this end the creation of a "European College" should be considered. Such an institution would provide experts with the financial and career infrastructure to move for extended periods of time without a disruption in their career paths and without disrupting their social security arrangements.

- Life-long-training programmes must be designed to reduce the polarising effect from the tendency to train even further already highly-skilled labour. Training programmes should be available for workers at all skill levels particularly in services, as human skills are a crucial input to innovation in that sector. European accreditation standards would permit cross-border mobility at more levels of the labour force.

### Funding of innovation

The issue of venture capital has been raised and addressed in previous EU policy. For example, in April 1998 "Risk Capital: a key to job creation in the European Union", which included a proposal for an Action Plan, was adopted by the Commission.[7] This has resulted in many initiatives, relating not solely to employment, but also to innovation financing. Nonetheless, the communication "Risk Capital: Implementation of the Action Plan. Proposals for moving forward" concluded that: " while some progress is being made towards the construction of an integrated pan-European risk capital market, it is very uneven among the Member States and the EU still suffers some major weaknesses".[8] The venture capital issue is worthy of further policy focus.[9] These initiatives are extremely important, should be further

[7] Risk Capital: A key to job creation in the European Union. European Commission, SEC(98)552

[8] Risk Capital: Implementation of the Action Plan. Proposals for moving forward. European Commission, COM (1999) 493. Some of the measures proposed in the Risk Capital Action Plan are integrated into the Financial Services Action Plan. The broad aim of the latter is to reduce the cost of capital to European firms. (Financial Services: Implementing the framework for financial markets: Action Plan. European Commission, COM (1999) 232.

[9] We should also point out, as addressing the difficulties of the venture capital market, the Innovation and Technology Equity Capital (I-TEC) initiative, and the catalysing role of the European Investment Fund and that of the European Investment Bank. Some of these initiatives are the result of the implementation of the action Financing Innovative Technology (FIT).

developed, and deserve a high priority. Ongoing efforts are needed to facilitate the financing of innovative activities and innovative SMEs, not only in ICT, but in a broad range of industries. The (perceived) ability to obtain external finance from various sources and in various forms can influence the start-up options and actual decision to start considered by potential entrepreneurs, thereby stimulating entrepreneurship and exploitation of innovations.

The European system of financing innovation is still very much bank focussed. While venture capital finance is increasing in Europe, it is still much lower than it is in the US. Measured as a percent of GDP, European venture capital is roughly half that of the US. Further, the European "small cap" stock markets (EASDAQ, Euro.NM and AIM) are very small compared to the American NASDAQ both in terms of market capitalisation and the number of firms listed. Although they seem to catch up now, some of these markets are still underdeveloped, too fragmented and therefore lack liquidity. Independent of the amount of venture capital in circulation, an extremely importance difference between Europe and the US is that in Europe venture capitalists invest in firms which have some proven track record. What is needed is more seed capital. As mentioned in the Risk Capital Action Plan, an important source of this seed capital can be private investors or business angels, though this source is much better developed in the US. These business angels are important financiers however, for more than one reason. Not only do they provide the much-needed seed capital, but they are often (retired) entrepreneurs themselves with valuable expertise and are able to assess the potential value of an idea or innovation. They can also provide access to networks such as other investors, suppliers, clients and partners.

There are two types of responses to the situation just described. One is to improve the operation of the venture capital market. One of its claimed short-comings is that there is a mis-match between supply and demand. European venture capital exists, but a significant portion of it may be invested outside Europe. This suggests that the expertise of venture capitalists in Europe does not match the expertise of innovating firms. To some extent this failure can be addressed by the provision of better information regarding the skills and experience of both sides of the market.

The other type of policy response is to attempt to move banks towards more "venture" investments. Banks typically lack the expertise needed here. One way to address this is to create or improve bank links with this type of expertise, of which there is plenty. Universities or research institutes have the abilities to evaluate at least the technical sides of investment proposals; marketing agencies have the abilities to evaluate market potential of proposals. Improving bank contacts with both types of institutions would increase their ability to increase the proportion of their investments in "risk capital". It must also be acknowledged that learning and knowledge are important in the evaluation of innovative ideas by banks and institutional investors. Initiatives like technology rating as well as training of business and market analysts could aid in the further assessment of ideas and hence, technology financing. To create a *European* venture capital market implies trans-national mobility of not only capital but also of expertise, so there is call for a European network of expertise on which banks and venture capitalists can call.

A further issue affects not only venture capital but capital markets more generally. As firms invest more and more in intangible assets, there is a more and more pressing need to be able to place a market valuation on those assets. Thus a standardised means of including intangibles in the financial statements of firms becomes urgent.

Related to financing are the laws with respect to insolvency and bankruptcy. In this respect it is important to realise that founding an enterprise is a learning experience. Those who fail the first time, often try again. These second tries are likely to be more successful than the previous experience, if the entrepreneur has learned from it. The communication on the implementation of the Risk Capital Action Plan shows however, that actions in this field are still limited and need further development. Further, it must be acknowledged that fiscal conditions can have both positive and negative impacts on incentives to pursue innovative activities. Member states run a series of tax incentive measures, especially on corporation tax but also on personal tax to promote innovation in enterprises. The Commission can play a co-ordinating role to alleviate or if possible prevent “tax wars” between member states, and to provide information on best practices in this area.

- The ability of banks and venture capital funds to tap European technological and entrepreneurial expertise regarding new and novel technologies must be improved by creating a European network of expertise, including technical (from the European research community), and entrepreneurial expertise, (from business angels for example) on which banks and other financing institutions can draw.

- Standards for reporting and documenting the value of intangible assets should be explored. A European standard is desirable to facilitate a European capital market and thus the EU can play a co-ordinating role.

- An innovation-friendly fiscal environment needs to be further developed. A review of taxation policies should be undertaken to evaluate their effects on innovation activities, and taxation should be designed considering their stimulating effects on innovation.

## Glossary of Terms

| | |
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| Absorptive Capacity | The ability of a firm to integrate (new) knowledge into its own knowledge stock so as to be useful in its activities |
| Business Angel | Wealthy individual, often a successful entrepreneur who invests time and money in very early-stage firms |
| Clustering | Geographical agglomeration of activity, either production or innovation activities, driven by the presence of external economies |
| Diffusion of Innovation | The process of adoption of an innovation for use throughout the economy, spreading from its original source or site, to other sites |
| Diffusion Policy | Policy aimed at facilitating the movement of an innovation from its source to agents throughout the economy |
| Innovation (an object) | A novel product or practice that is made available for application, usually in a commercial context. Typically, various degrees of newness can be distinguished, depending on the context: an innovation can be new to a firm (the agent), new to the market, or a country or region, or new globally |
| Innovation (an activity) | The process of creating an innovation, often identified with the commercialisation of an invention |
| Innovation Policy | A set of policy actions to raise the quantity and efficiency of innovative activities whereby "innovative activities" refers to the creation, adaptation and adoption of new or improved products, processes, or services. |
| Invention | A new idea, that has not yet been commercialised |
| Intellectual Property Right | Patent, Copyright, Trademark or Design Registration; legal structures to give ownership rights to creators of new ideas |
| National System of Innovation | A geographically defined system in which various agents interactively generate, use and exchange new knowledge, which is of economic use |
| Patent | The sole rights to the exploitation of an invention, usually for a 20 year period |
| *R&D* | |
| Applied R&D | "Mission-oriented" R&D aimed at solving some particular problem often commercial in nature |
| Basic R&D | "Exploratory" R&D aimed at understanding fundamental or generic principles of scientific and technological processes |
| R&D Indicators | A variety of indicators which can be used to measure the innovative efforts of agents (e.g. firms) or nations. Input measures include amounts spent on R&D. Throughput measures include patents. Output measures could include the percentage of sales generated by new products |
| *Knowledge* | |
| Codified Knowledge | Knowledge recorded in codes that can be stored for access at other times and places |

| | |
|---|---|
| Disembodied Knowledge | Knowledge which is disentangled from the product or service itself, for instance through patents or licenses |
| Embodied Knowledge | Knowledge which is captured in products or services |
| Tacit Knowledge | Knowledge that has not been codified |
| Risk Capital | Equity financing to a company during its early growth stages. It covers investments by business angels, venture capital and stock markets specialised in SMEs and high growth companies |
| Scale Economies | A property of the production function whereby the marginal cost of production increases or decreases as the scale of production increases |
| Spillovers | Leakage of knowledge from the generating agent to other agents |
| *Technical Change* | |
| Linear Model of Technical Change | The conceptualisation of technological change as a unidirectional sequence, in which innovation appears as a step or stage, following invention (or applied R&D), which follows basic R&D and precedes diffusion. There are no feedbacks among the stages in this sequence |
| System Model of Technical Change | The approach that focuses on the interactive links between different stages in the innovation process and the composition of these linkages. It assumes that technical change is an emergent property of the whole set of interactions |
| Systemic Failures | Situations in which systems get trapped in local (but not global) optima (whether static or dynamic optima). These can arise from different elements of the system being badly co-ordinated or, for example, from lock-in effects |
| Technology Policy | Policy aimed at affecting the actions of agents in a system, with regard to their choices of technology and the creation of new technological products, processes or services (These actions can refer to conducting R&D, innovating or adopting new technologies) |
| Venture Capital | Subset of private equity investments in an unquoted company. One can roughly distinguish between seed capital, start-up capital (initial stages) and expansion capital (growth stages) depending on the timing of the investment |

## Abbreviations and Acronyms

| | |
|---|---|
| CAVR | Community Added Value Requirement |
| CERN | European Organisation for Nuclear Research |
| CIS | Community Innovation Survey |
| CMS | Carnegie Mellon Study |
| CNR | Consiglio Nazionale delle Ricerche (Italian National Research Council) |
| CREA | Capital Risque pour les Enterprises en phase d'Amorçage |
| DG | Directorate General |
| EASDAQ | European Association of Securities Dealer Automated Quotation |
| EC | European Commission |
| EIB | European Investment Bank |
| EIF | European Investment Fund |
| EMBL | European Molecular Biology Laboratory |
| EPO | European Patent Office |
| ESA | European Space Agency |
| ETAN | European Technology Assessment Network |
| EVCA | European Venture Capital Association |
| EU | European Union |
| EURATOM | European Atomic Energy Community |
| EURO.NM | Nouveau Marché (Paris) + Neuer Markt (Frankfort) + Nouveau Marché (Brussels) + Nieuwe Markt (Amsterdam) + Nuevo Mercato (Milan) |
| EUROSTAT | Statistical Office of the European Communities |
| FDI | Foreign Direct Investment |
| FIT | Financing Innovative Technology |
| GDP | Gross Domestic Product |
| ICT | Information and Communication Technologies |
| INLOCO | Industrial Districts and Localised Technological Knowledge |
| IPR | Intellectual Property Rights |
| IMRI | Institut pour le Management de la Recherche et de l'Innovation |
| I-TEC | Innovation and Technology Equity Capital |
| IT | Information Technology |
| LIFT | Linking Innovation, Finance and Technology |
| MERIT | Maastricht Economic Research Institute on Innovation and Technology |
| MIP | Mannheim Innovation Panel |
| MIP-S | Mannheim Innovation Panel for Services |
| MNE | Multinational Enterprise |
| NASDAQ | National Association of Securities Dealers Automated Quotation |
| NICs | Newly Industrialised Countries |
| OECD | Organisation for Economic Co-operation and Development |
| PACE | Policies, Appropriability and Competitiveness for European Enterprises |
| PC | Personal Computer |
| R&D | Research & Development |
| SMEs | Small and Medium-sized Enterprises |
| SPARC | Space Physics and Aeronomy Research Collaboratory |
| STEP | Studies in technology, innovation and economic policy |
| STP | Strategic Technology Partnerships |
| TSER | Targeted Socio-Economic Research |
| WIPO | World Intellectual Property Organisation |
| WTO | World Trade Organisation |
| ZEW | Zentrum für Europäische Wirtschaftsforschung (Centre for European Economic Research) |

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# Technical specifications of the contract

**Title**: **Innovation policy in a knowledge-based economy**

## 1. Background

Innovation theory and policy in the last decade was characterised by the orientation, away from earlier linear models of technology push strategies, to a systems approach, where technology supply is not considered the sufficient precondition for innovation, and where emphasis is laid on technology diffusion and the absorption of new technologies and processes.

At Community level, this development towards a systems approach was reflected, amongst others, by the Green paper on innovation and by the Action plan for innovation in Europe, where not only research and its orientation to markets is addressed, but at the same time the legal, regulatory and financial framework for innovation and the factors shaping an innovation culture.

Nevertheless, whereas the traditional approaches to innovation theory and policy are still largely based on industry, there is increasing recognition that the transformation towards knowledge based economies has to be taken more into account, as evidenced by:

- the emergence of information technologies, and their gradual penetration of and fusion with other technologies, changing the structure of whole industries;
- the arrival of the information society and the web, giving new perspectives for the access to and the accumulation of knowledge at enterprise level, transforming the interaction between enterprises on the markets, and reshaping the content and the characteristics of traditional activities, goods and services;
- the gradual shift towards service oriented economies, market- and non-market services alike, with growing shares of employment and wealth creation in the service sector, frequently based on knowledge intensive activities;
- the globalisation of the economy, resulting in an acceleration of structural changes, and the role, in this respect, of mobility of people at regional, national and Community level, and of flexibility in the acquisition of competencies;
- the more and more perceived need to have efficient decision making processes at the various levels of enterprises and the society, to balance long and short term orientations, and to asses the impact of the granting of incentives vs. the risk of exclusion.

In May 1993, the EIMS project "Maastricht memorandum for an integrated approach to European innovation and diffusion policy" was particularly valuable to guide EIMS work towards the new systems approach. A small working group of innovation policy researchers of high reputation was able to synthesise the new approach to innovation policy, to establish the link between theory and policy and to give a new orientation for the subsequent project activities.

A similar project should now assist in the up-dating of present innovation policy approaches with a view to better address the implications of a knowledge based economy, in particular with respect to SMEs, and for their integration in EIMS work.

## 2. Study objectives

The objective of the project is the provision of expertise in innovation theory and policy as input for further EIMS work.

This should be done by a small working group of innovation policy researchers of high reputation, which would synthesise new approaches to innovation theory, establish the link between research and policy, give advice on the design and implementation of current activities and develop long term perspectives for EIMS work relevant for innovation policy initiatives of the Community.

The main target group of the study is policy makers at Community and Member states level, the public R&D organisations, industry and institutions involved in the transfer of research results into industrial applications. Dissemination of the results is an important objective of the work. The target audience requires a precise analysis and, at the same time, a clear language.

## 3. Main tasks

The main tasks of the contractor are:

(1) *The setting-up and co-ordination of an expert working group*

The contractor will make proposals for the composition of a small working group of innovation policy researchers of high reputation. The members of the group will be designated in agreement with the Commission/DG XIII/D4.

He will take care of all the organisational and budgetary aspects, and cover fees, travel and other expenditures needed.

He will co-ordinate the work, assure participation of the selected members, prepare the meetings, take minutes and draft the proceedings.

With the help of the working group, the contractor will implement the following tasks:

(2) *Stock-taking and synthesising of innovation theory and policy approaches, with the particular objective of linking research and Community innovation policy.*

This task would imply the preparation of short analytical papers for discussion during the meetings. The topics of the meetings will be defined, together with the Commission, during the initial meeting of the group. The bidder is expected to present a list of main topics to be taken into consideration for an in-depth discussion during these meetings.

The output would have to be synthesised in a document on innovation theory and policy approaches in a knowledge-based economy, with particular emphasis on policies geared towards improving innovation in and technology diffusion amongst SMEs.

Approximately *10 meetings* of the expert group are planned under the project for this task, including a final meeting in Luxembourg or Brussels to present and discuss the results with other Commission services.

(3) *Giving advice on the design and implementation of current activities*

The group would provide on request short analytical comments and advice on working papers produced by the Commission services for the implementation of the Innovation programme.

(4) *Organising, with Commission officials, brain-storming meetings on longer term perspectives of innovation research and policy*

The group would hold brain-storming meetings with commission officials to provide insights into various different longer term strategies and actions that could be pursued at Community level, in the broad area of innovation and diffusion policies. The group would come up with suggestions with respect to further requirements for innovation research.

Approximately *3 meetings* of the expert group are planned under the project for this task.

## 4. Organisation

The preparatory work should be carried out in close co-operation with the Commission services (DG XIII/D4) to refine and develop priorities. The practical implementation of the project should start after an initial co-ordination meeting in Luxembourg.

Later on, working group meetings as set-out in point 3 above should be organised in Luxembourg.

Any subcontracting for the project would require prior formal approval of the Commission.

## 5. Expected deliverables

The following reports and documents are to be submitted :

- **One interim report** on the main task of the study as specified above in part 3 ‘Main tasks’, after 3 month of work..

- **Specific reports on request** to cover the main task n° 3 of the project as specified above in part 3 ‘Main tasks’.

- **A draft final report** to cover all the main tasks.

- **The editing of a final report**

  **The contractor will deliver a final report containing a summary of key findings and policy conclusions of 5 to 10 pages maximum, the core body of the study of not more than 100 pages including graphics and tables, and the main supporting documents attached as annexes.**

  The final report is to be presented in English and in a form and quality suitable for publication. It will be delivered on paper and on computer diskettes, to an agreed format. The paper version will be professionally designed, including, where appropriate, photographs and charts, with a view to facilitate its diffusion among the target audience.

  With a view to facilitate diffusion of the results, the contractor shall deliver to the Commission services, three typescript, ready-to-print copies of the manuscript, together with all pictures, charts and other materials necessary for the completion of the manuscript, ready for production.

  The ready to print manuscript will refer properly to the funding of the study by the Commission under the EIMS as part of the Innovation Programme.

The report may be published separately by EIMS, under the authors' name, in an EIMS publication series. It may also be used by EIMS as part for an edited volume which would collect, integrate, present and/or synthesise the various EIMS studies so that they are available and accessible to industrial, public and policy audiences.

- **Presentation of results**

  The preparation and organisation of a final meeting in Luxembourg or in Brussels. in which the main results and achievements of the project are to be presented for discussion.

## 6. Time scale

The project is planned to start in November 1998. The bidder will give a detailed time scale for executing the various tasks of the project.

Work should, however, be completed by the end of July 1999 at the latest, unless otherwise agreed with the Commission.

## 7. Copyright

Before printing the final report, the contractor shall specify any parts of manuscripts, including pictures and graphs, on which copyright or any other right of ownership already exists of such parts from the titular holder(s) of such rights or from his or their legal representatives. Any cost for which the contractor may become liable for such permission shall be paid by him.

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