Building European Research Capacity

Proceedings from MUSCIPOLI Workshop Three

STRATA Accompanying Measures
Managing with Uncertainty in Science Policy

The Danish Institute for Studies
in Research and Research Policy
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Building European Research Capacity

3rd MUSCIPOLI Workshop

Managing with uncertainty in science policy

Athens, October 2002

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Forward by the Network Coordination

Building European Research Capacity

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In this report we present the proceedings of the third of three workshops planned within the project. The workshop was organized with the topic: "Building European Research Capacity", which is an issue high on the European agenda, and it took place in Athens in October 2002.

The workshop had participation from university researchers, researchers from government research institutes, research administrators, representatives from Federation of Industries and policymakers at national and regional level bringing together 18 participants with experiences from a variety of European countries and from the European Commission as well as from European Science Foundation and OECD.
A special thank to the Secretary General of Research and Technology, Mr. Dimitris Deniozos, The Greek Ministry of Development, and to the University of Athens for supporting the meeting.

On the basis of the presentations collected and presented in these proceedings a number of discussions took place and a summary of the discussions and conclusions are presented in a separate chapter.

The workshop was organised by professor Lena Tsipouri and her assistant Evita Paraskevopoulou and as coordinator of the project I want to thank both of them for their great effort in organising the workshop.

The report is edited by professor Lena Tsipouri and Evita Paraskevopoulou from the University of Athens.

Karen Siune
Co-ordinator

January 2003

Executive summary

The basic message from the analyses and discussions on capacity building is that ***in an era of high uncertainty,*** as the one Europe is currently living in, there are no universal recipes for success and ***policy makers need to experiment and take risks, trying to find new ways to invest that will lead to higher social returns on R&D investment***. Research is already an activity loaded with high uncertainty stemming from market failures, principle-agent problems and network dynamics. It is argued that this basic uncertainty is further reinforced by current event. There is no doubt that we are living through a period of serious transformations:

- the technology and political consensus leading to globalization increase pressures for competitive production and in this model European firms, regions and member states can only compete to the extent that they adopt a knowledge-based model of production;
- the enlargement into a group of structurally different economies triggers new challenges and requests differentiated instruments;
- the effort to pass from established national research policy systems into a better articulation of the supranational (European) – national and regional levels, with new forces and targets calls for better understanding an broader views on coordination, expectations, framework conditions and types of funding.

The first from the above sources of uncertainty applies to the whole world, the second and third are particular to Europe and there is an amplifying effect, when trying to deal with all three new sources at the same time. In this context the workshop tried to answer two types of questions:

1. *Which are successful established country or policy models* from which policy makers can learn how to select the size, direction and methodology for capacity building?
2. *Which new types of measures are suggested to experiment with* for those policy makers who wish (or are allowed to) break new ground and test alternative hypotheses?

The problem with country models is that one cannot identify success stories that fit all needs. The two countries that could leapfrog in the '90s in capacity building, which led to long-term high growth were Finland and Ireland, which followed quite different approaches. The common denominator was the emphasis they both laid on human capital. Technologically advanced big countries also demonstrate persistent success in terms of innovation capacity, so to reduce uncertainty and meet the Barcelona target all emphasis appears to lead to the reinforcement of those big and already successful systems. But this would be contrary to the basic philosophy of the Treaties, thus even if difficult to incorporate *cohesion has to be a key element in science policy*. This applies both to the cohesion countries, which need to apply more ambitious and result oriented policies and to the accession countries, which should eliminate persistent problems, the crucial one still being the lack of demand for commercializing research results.

Going beyond country dimensions into the constituent elements of capacity building there is clear evidence that there is a ***virtuous circle in capacity building***: talented researchers go to prestigious research laboratories, which dispose of good scientific equipment. This leads to even higher quality research that provides opportunities for further research funding attracting new talent and more funding for state-of-the-art research equipment. This virtuous circle is further strengthened by the new strategies of multinationals to locate R&D facilities in areas where they can pick ideas, hire talented graduates or sub-contract part of their own research. This virtuous circle suggests the need for combined efforts in the excellence centers and the adoption of innovative approaches in

- *the rules for purchasing research equipment*: it needs to be viewed as a package of provision, maintenance and training and in that sense differs from the classic public procurement rules, but also in a perspective of sharing very complex and expensive new vintages to assure access to them to the highest possible number of research laboratories;
- *human capital*, which should on the one hand be expanded to include organizational aspects that lead to the notion of intellectual capital, but also to make it clear that talent is a very scarce resource that may lead to diminishing returns if not attracted from wherever it can be found; this implies change in national policies where university regulation needs to liberalize and support for intra-European mobility needs to be strengthened. At the European level this should influence inward migration policies;
- specific policy *rules need also to be examined to increase efficiency*: using methods alternative to peer review, mobilize new actors such as public or private research foundations, apply measures that capitalize on externalities that span national boundaries, compete with the US for R&D inward investment. Interdisciplinarity and networking, although in the agenda, need to take a fresh look and benefit from the creation of rewards and the clear understanding of mutual benefits.

While this virtuous circle is a blessing for organizations, countries or regions, which are part of it, it creates barriers to entry to those left outside the virtuous circles. For them there is a danger to enter vicious circles of low quality research, since their best constituent elements may try to aband organizations or regions with lower performance. For those actors it is very important:

- to adopt research strategies (related to expected realistic innovative performance) and prepare carefully selected targets and steps needed to achieve them; not all regions need to achieve the 3% target, but they all need to set benchmarks deriving from their economic structures and a potential restructuring;
- adopt all known instruments (like assessments, evaluations and foresight) to better manage science *and technology* policy;
- emphasize networking and public-private cooperation, which have already their own dynamic in the virtuous circles;
- adopt an active human resources policy leading to systematic improvement of intellectual capital and (to the extent that they cannot afford their own) network with prestigious organizations to share high tech research equipment.

Needless to say that in this context the European Commission has a very active role to play in supporting externalities from cross-border activities, offer through benchmarking and open coordination a more ambitious environment for Europe as a whole and last not least help gain new insight and evidence for science, research and innovation policy, which need to be closely link. Science policy research but also laboratory studies in R&D constitute the basic elements in this direction.

Chapter 1: Introduction

1.1 The Outline of the workshop

The 3rd Workshop of MUSCIPOLI aimed at the investigation of European Research Capacity. The issue is by itself complex enough and it addresses several thematic and geographical dimensions, but it is further aggravated by the fact that the European Research system is in a process of change through the pressures of globalization, the conception and implementation of the ERA, but also the enlargement and seminal technological changes and new global alliances. The idea of the workshop was to investigate these dimensions separately and then draw conclusions that can be of relevance for a broader policy debate or take the form of concrete recommendations.

The presentations followed a thematic scheme that starts with the discussion of country models (Section 1.2) or country-specific features, to find out from a descriptive points of view success and failure stories to learn from. Then experiences of specific actors, notably industry and foundations were presented (Section 1.3). In an effort to keep the time schedule within limits universities and research institutions did not constitute a separate entity as they were included in all presentations and in particular in those referring to research equipment and the ERA. From these two points of view two major presentations raised the issues on how to build capacity, which is broken down into human and physical capital, i.e. researchers and scientific equipment (Section 1.4) A final Section 1.5 was dedicated to the integration of those isolated components into the dynamics of change into the ERA, the Barcelona target and most importantly into the changing world of global competition, where politics, policies and corporate decisions play a major and interwoven role.

In this introductory chapter abstracts of the individual papers appear in the order they were presented in the workshop. Chapter 6 takes the main messages into conclusions, issues and recommendations, following a very similar logic, yet integrated to better reflect policy lessons rather than analytical concepts.

1.2 Lessons from different country models

Four papers were presented in this first session (one was borrowed from a previous research to make up for a last-minute created gap) on

- the Nordic experience, labeled in general as a success story,
- the cohesion countries, where research capacity lagged and continues to lag behind but was built up rapidly thanks to the Community Support Frameworks in the last decade,
- the accession countries, which have important research capabilities but need new institutional approaches and
- an overview of big versus small countries and regions and how this affects the achievement of the Barcelona target.

Following sessions and presentations contributed to building up a the topic:

<u>Building European Research Capacity: Thought from the Scandinavian experience: K. Siune</u>

The paper deals with the uncertainty inherent to science policy initiatives when it comes to the issue “building European research capacity”. Some uncertainty is attached to the instruments used for building the research capacity but even more to the impact of the instruments. Before starting to build research capacity one should keep in mind that there are different starting points among the EU member states and there are there different dimensions regarding to the basic elements (infrastructure, human capital, institutions). Thus expenditure on R&D and the instruments for building capacity are provisional to a country's advantages and drawbacks.

The paper points out the main capacity building instruments, along with some key success factors, but strongly points out that such initiatives are closely bounded up with uncertainty. It also suggests that there is not one unifies ***Scandinavian model***, but lessons from the Nordic countries can be drawn individually and suggest that small, advanced, open economies can do very well in terms of successful R&D and persistent innovation was of major interest in this context.

Conclusions from the experience of the use of the Structural Funds for Capacity Building in the Cohesion Countries and Less Favoured Regions: A Report to DG Regional Development by CIRCA

This paper draws on the unique experience of historically technologically less advanced countries and regions that found themselves at the margin of competition when the Single European Act was adopted. The opportunities to receive sufficient transfer funding to put their development process in motion combined with the emphasis put in the planning process on the need to build research capacity led to important lessons learned, like:

- the need to increase hard and soft elements of the research system in parallel avoiding "easy" funding to flow to underutilized hard infrastructure,
- the immense role played by human resources,
- the need to reformulate management systems and institutions, which is very close to the lessons drawn from the accession countries' experience.

Targets and instruments for capacity building in the accession countries: A. Inzelt

After the latest major changes in the economic and political systems of the transition countries, the challenge of quick adjustment into the new technological and economic environment emerges as the crucial issue. Among others the countries in transition have to increase their capacity in the area of modern science and technology and in innovation policy making. Two special issues are examined: 1) the penetration of modern policy-making instruments into Hungary and 2) the presentation of initiatives to upgrade to intellectual capabilities for S&T and innovation policy-making in Central and Eastern European Countries (CEECs).

As far as the first issue is concerned, there is a classification of the main instruments of modern S&T and innovation policy-making needed urgently in these countries into four groups: Evaluation, Foresight, Technological Assessment and Indicators. Along with a brief presentation of each one of the above topics, some interesting and quite representative data give an overall view of performance of a country in transition and indicate some possible problems and solutions.

The special case of the *Center for Innovation Policy Research and Education (CIPRE)* is presented as a model helping accession countries to overcome their current drawbacks. This international joint program intends to serve several purposes strongly attached to the lack of capacity in modern S&T policy-making in the CEECs, by taking serious action in training and arising interest for such issues.

R&D, Innovation and Productivity Growth: some thoughts on the Barcelona Objective: Y. Katsoulakos

Using the Barcelona Objective of 3% expenditure on R&D as a starting point, several issues arise regarding the type of policy mix that should be adopted in order to fulfill this target successfully, place more EU countries among the global innovators and enhance EU competitiveness. It is made clear that in the absence of any policy measures, R&D is not likely to be at the social optimal levels, and that calls for an active government involvement both through direct provision and funding. The provisional policy measures can be classified into two categories: measures that improve framework conditions and financial incentives.

Given the above, the importance of country level decisions is evident and questions like "which EU countries, with regard to their current economic status, should mainly focus on R&D investment?" and "which is the best way to give EU a big push, as far as competitiveness is concerned?" become an issue. Big countries may have different systems but their relative weight makes them the key actors in the achievement of the Barcelona and Lisbon targets.

1.3 Actors in capacity building: Going beyond the public research system alone

All theoretical and empirical evidence points at the very important role of the productive sector for the effective exploitation of research results. Policy makers, individual companies and collective actors have realized that and are proceeding with new ideas and emphasis on technology. Public-private interaction in this context increases. A paper from a region, which traditionally lagged behind and tries to reverse this situation appeared proved a very important source of information.

At the same time the role of foundations is studied in the case of the European Science Foundations, to examine the potential role of these, usually less studied actors in the new context.

Issues on the university and public research organisations are discussed in the context of Sections 4 and 5, in their respective angles.

Dealing with the innovation deficit and supporting research and development actions in the EU: Review and Proposals: T. Alexandridis

The importance of research, commercialisation of new knowledge and development of innovative products and services constitutes one of the key factors crucial for the enhancement of economic performance and competitiveness. It is a fact that European economies (in average) are way behind the US economy, in terms of productivity rates and proportional benefits. This obvious deficit can be attributed to the limited action taken by the European firms in the research area, due to a number of internal and external factors such as:

- the unfavourable balance of opportunities, pressures and incentives for innovative actions,
- less support in risk taking, entrepreneurship and adoption of new technologies,
- the minimal resources allocated for the creation and dissemination of knowledge,
- the European educational systems,
- the EU tax systems and the regulatory and fiscal frameworks.

Proposals aiming at strengthening the research potential and correcting the existing innovation deficit focus on education and training, a better relationship between research, industry and academics and greater willingness to embark on innovative actions specially based on the core role of SMEs. In order for the proposals to be successfully implemented, the participation of three vital bodies is crucial: the governments, the companies and the universities and research institutes.

New Directions, New Capacities – the Role of Foundations: the Specific Case of the European Science Foundation: J. Smith

The need for a stable source of research support is obvious all over Europe and this role is attributed to foundations. Apart from the financial contribution, which is undoubtedly important, foundations also provide the means for further exploration of new research ideas and directions, thus they increase research capacity.

The European Science Foundation (ESF) illustrates the role of foundations, while it sets a good example for the European reality. It is a publicly- funded body of large scale and size and functions a lot different than private foundations. Research capacity building initiatives are usually examined through the operation of four conceptual approaches of «Flexibility», «Interdisciplinarity», «Risk taking» and «Think Tank» function and by eliminating research constrain. Some good examples of European Science Programmes and Initiatives are presented and prove the determining role and contribution of such foundations in the European Research Area .

1.4 Key components for capacity building: human capital, physical capital and their interaction

The two building blocks of research capacity building are human capital, notably researchers and research support personnel and physical capital in the form of scientific equipment, and expenditure necessary to operate it. It goes without saying that the two are fully complementary and none can function without the other. The two papers in this session pointed out the scarcity of talent in the European research personnel and the importance of good management of resources for research equipment as its cost and complexity increases. They both suggest that policy makers are faced with crucial decisions and management challenges in that respect.

Researchers in Europe: A Scarce Resource?: M. Bertilsson

Some indicative data on European Human Capital indicate that European figures concerning R&D developments are pointing at many diverse directions. The individuality of human capital, talent and scientific productivity as development resource is the core of analysis in special or general theories of scientific progress as well as organizational and cultural theories and justifies the blur but determining role of human resources as far as research capacity is concerned.

Europe is lagging behind the US in terms of attracting talent and it is in fact losing out talents to the US. It also attracts less talented people from outside the OECD area. Thus it will be necessary to face the problem of a potential bottleneck in research personnel in the future and address it both with science and migration policies.

Policy for Research Infrastructure: Some lessons from a comparative study of access to leading edge research equipment: K. Flanagan, K. Malik, L. Georgiou, P. Halfpenny

Continuing progress in science demands ever-higher performance standards from those universities who wish to remain at the ‘leading-edge’. Also the competitive position of a nation’s science base is affected by sufficient access to scientific research equipment for scientific researchers. Drawing on the perceptions and opinions of researchers and heads of departments at some of the most research-intensive universities in the UK and USA, the paper presents key findings from comparative case studies of access to three different types of high-specification research equipment: (High field Nuclear Magnetic Resonance (NMR) spectrometry (in chemical or biosciences research), Electron-beam Lithography (in physical sciences research), High Resolution Electron Microscopy (in physical sciences research).

The strongest arguments presented highlight the fact that funding of leading edge UK research groups should be less piecemeal and uncertain. Consistency and constancy of support are vital to nurturing high quality research. Also human resources and equipment acquisition are intimately interlinked but this is barely acknowledged in the context of present funding systems.

1.5 From national to European research capacity building: Changes and new challenges

As uncertainties grow and global competitive pressures increase national systems alone are insufficient to cope with the new challenges. In this spirit the European Union is trying to pool resources together, streamline efforts and eliminate or at least reduce duplications. This is happening in a period with both internal and external pressure: On the one hand the ERA has to be created in a way that will not create tensions and where intra-European cohesion remains high in the political agenda, constituting a constraint to an unlimited concentration of R&D resources. At the same time externally global pressures seem to favour the US as a location for new R&D investments. Finding a good balance and meeting the Lisbon and Barcelona targets is a major challenge for national policy makers in their national capacity but also as part of the emerging European Research Area.

Building RTD and innovation capacity in the regions: objectives, priorities and means in the context of the European Research Area: *Synergies between Community actions: achievements, opportunities and limitations:* D. Corpakis

The progressive build-up of the knowledge based economy in Europe calls for increased efforts for building capacity for research, technological development and innovation in the European regions (sub-national entities). This is especially true not only in the less developed regions of the European Union (EU) but also in those areas going through profound economic restructuring. Efforts to reach this goal have focused traditionally in providing and improving relevant infrastructure (university and laboratory space and equipment; improved communication facilities (transport infrastructure and telecommunications)) and energy provision. Today it is firmly believed that this policy, while necessary in the early stages of a process for building up capacity, is not sufficient and ultimately not sustainable if it is not coupled by a strategy that focuses on building technological and innovation capacity in a region in dynamic terms. EU past experience with both approaches (Structural Funds and the RTD Framework Programme via the RIS / RITTS/ RIS+ initiatives) makes it a world leader in supporting the knowledge based economy in the regions.

However major weaknesses are still encountered, namely on the delivery of these strategies and their successful articulation. While positive results may be registered in individual policies, sufficient synergies are not yet accomplished between respective Community initiatives. In the context of the developing European Research Area (ERA), the 6th Framework Programme for RTD (2002- 2006) will attempt a major mobilisation of actors at national and regional level, to increase this synergy and make the most of the available Community instruments. This would be notably achieved through activities that will support and valorise the regional dimension of Community research actions in relevant areas of the 6th FP and policy development surrounding the progressive build up of the ERA. In particular these will focus on implementation of the ERA-Net scheme (co-ordination and mutual opening of research schemes and initiatives at national and regional level) as well as in other areas of the FP where the regional dimension may have an important role in stimulating or organising better research efforts. Improved interactions will be sought between RTD instruments and the Structural Funds, notably the FEDER Innovative Actions.

Towards 3% GERD and impact on Capacity Building: M. Rogers

The significant role of R&D as a driving force for a competitive and dynamic knowledge based economy is already proven and accepted and sets the basis of the 3% target for Europe. This target cannot easily be met and for that reason one should look thoroughly into the dimensions it involves and affects. As far as its indicators (BERD, GERD) are concerned it is pointed out that Europe lies far behind the US. The paper presents the determining factors for such a difference and indicates some proposals.

It involves a brief analysis of: the industrial sectoral structure and its differences among EU and US, the diversity of national and regional situations within EU, areas for concerted action, human resources and the classification of intellectual capital, the links between industry and academia, entrepreneurship, intellectual property rights, research supportive regulations, competition, financial markets, macro-economic stability and favorable fiscal conditions and implications for research capacity. All these factors suitably combined will set the basis in order for policy makers to response to the evident need for capacity and towards a concerted European Action.

Capacity building and the economics of R&D: Towards the design of relevant European policies: D. Foray

Approaching the target of 3% of GDP on R&D is the next step to be taken by the EU member states, in order to eliminate the R&D gap between the EU and the US. The reasons for this gap should be first sought and then faced. During this effort the policy makers are called to indicate the right policy instruments aiming at R&D capacity building, while setting a suitable framework.

The complexity of the political and institutional system in Europe makes it even more difficult for policy measures to be efficient. In order to simplify the research capacity building issue, one can resolve the matter in 5 dimensions: commercial R&D capacities, basic research capacities, strategic capacities, network capacities and revolutionary capacities. Each one of these pillars is individually analyzed and their combination gives a more complete approach

Challenges from the globalization: MNC networks and proximity arguments: L. Tsipouri

Until the '90s multinational corporations were known (with few exceptions for argo-food and special drug research) to concentrate their research capabilities in their home country close to the headquarters, but since the strategic changes are observed empirically that are now also theoretically underpinned. In the '90s there is a massive increase in transnational research investments: multinationals become global in their R&D design. Some countries and regions emerged as major winners in attracting foreign direct investments in research, while others were completely left outside this process.

A key policy question is thus how can national, or regional capacity building be improved through foreign direct investments (FDI) active in R&D? Is there a role for policy makers, as firms source research and innovation from multiple locations around the globe? Some regions point out diverse ways on how to benefit from FDI in research capacity building: Aachen, Sophia Anitpolis amd the Irish Development Authority, the North Carlina Research triangle and San Diego in the US are only a few cases to mention, where FDI research increased as a response to sound policies and not initial market messages. But these success stories are not easy to replicate: While global firms do invest abroad for R&D now, they are only attracted by locations with a strong research base. They invest in other research-intensive countries or regions suggesting new patterns of agglomeration.

Conceptualizing European Research Capacity: E. Shove

The relationship between human capital and the institutional settings is determining for building research capacity either within national or supra national systems. A conventional model is presented, showing the great interaction among its members as well as the ability of one researcher to take part in several national or international research arenas at the same time. The invisible routes among networks create other networks and this proves the importance of shaping correctly the structure of institutions in a way, which brings back the benefits of international interaction.

Chapter 2: Lessons from different country models

2.1. Building European Research Capacity, References to the Nordic countries

Karen Siune
The Danish Institute for Studies in Research and Research Policy, Denmark

This workshop concentrates on the topic "building European research capacity".

As a part of the MUSCIPOLI project this third workshop addresses the relationship between the activities contained in building European research capacity and the MUSCIPOLI's central purpose: getting more information about "Managing with uncertainty in science policy".

How uncertain are the science policy initiatives when it comes to the issue "building European research capacity"? Some uncertainty is attached to the instruments used for building the research capacity but even more to the impact of the instruments! How does uncertainty influence the type of managing we have as the object in the MUSCIPOLI project? This presentation concentrates on the instruments, and the intention is to make a frame of reference for the discussion at the workshop and to reduce the uncertainty with respect to the instruments used.

Science policy: how to build a European research capacity? Can we talk about different regional models?

The political challenge has recently been the same everywhere in the European countries independent of the national situation. In the global economy innovation and development are perceived as the keys to success in the market place, and R&D and innovation is perceived as the key to economic growth within the European Union. And increasingly we hear warnings about "brain drain", defined as the risk in Europe for loosing research capacity in form of trained people going abroad.

Actors within science policy refer to a need for European interaction in the science area, not to waste time and money competing against each other inside Europe. We are aware of the demand for European collaboration and the need for scientific integration. The Lisbon declaration is the most prominent example. In January 2000 the European commission adopted a Communication proposing the creation of a European Research Area (ERA). The aim is to strengthen the coherence of research activities and policies throughout Europe with the intention of increasing the impact of European Research. At the Lisbon European Council in March 2000 the Heads of State or Government fully endorsed the project.

Science policy has become a European policy area. All EU-member states have recently at The European Council meeting in Barcelona in March 2002 agreed " that overall spending on R&D and innovation in the Union should be increased with the aim of approaching 3 percent of the national gross product (GNP) to be allocated to R&D by 2010". This in itself is political goal planned for all member states. But what instruments can be used to reach this goal? In the agreement it was included that "Two-thirds of this new investment should come from the private sector". The actions and the outcome shall be measured at the national level.

In this respect the frame for science policy is more or less the same across Europe, and all governments refer to science and technology development as the prime source of economic growth. But the starting points for the creation of a research capacity have been different and so have the economic structures, the company structures and the educational structures and capacities. Inside the Union there are differences, but comparing EU with developing or with very developed nations like US show even greater differences.

In the planning of this workshop I was asked to look at the Nordic countries and from that assignment it is natural to see whether they as a group or as single countries can be taken as an example of best practice for science policy. A “yes” or “no” to that question predisposes a closer look at the different Nordic countries? First: Is it the same instruments that have been used in all the Nordic countries?

Second: If so, the next questions naturally will be: are the instruments applied in the Nordic countries specific for the Nordic or Scandinavian countries or are they applicable in all other European countries? If no, can we talk about different models for building European research capacity? Is there a special UK model? Is there a special French model, a German model or is it the same type of instruments used all over Europe? I do hope that we at the workshop can take this discussion.

Elements in the European Research Capacity?

First and foremost it is necessary to define “European research capacity”. What is the object for analysis at this workshop?

Capacity building in research and development refer to:

- Physical research infrastructure (research equipment, building and other facilities),
- Human Capital (Researchers, technicians and an overall attractive level of the workforce),
- Institutional building (legal framework, support mechanisms and environment conducive to innovation).

These elements of European research capacity are all results of the science policies at both the national level and the European level. Funding of R&D is a result of a policy; special initiatives are a result of a policy. Building institutions for education and researcher training is also a result of policy.

In the following we will take a closer look at a number of indicators of some of the key elements of the national research capacities that lay the foundation for the aggregated European research capacity. The main focus is on the number of researchers and the R&D expenditure, but a number of other important instruments will also be mentioned.

Human capital as a key element in European research capacity

The human capital element of European research capacity can be defined in one of three ways, ranging from a broad definition including all European researchers to a narrow definition including only the researchers involved in integrated European projects:

1. Sum of all researchers in Europe, adding all types, independent of their research activity, field or whether they are public or private or
2. Sum of nationally based researchers involved in one way or another in research cooperation with a limited number of European researchers outside their own country (the partly involved European researchers) or
3. Integrated network of European researchers involving researchers from several or all European countries.

For the purpose of the discussion at this MUSCIPOLI workshop definition no. 1 is relevant as a starting point. A key question is: what has been done at the national level to build up research capacity in terms of Human Capital.

For Commission initiatives with the purpose of increased European integration it is definition no. 3 that is the most relevant definition. The creation of the *European Research Area* (COM (2000)6 and COM (2000)612) aims to an open co-ordination with the different national programmes and other European organizations, creating a more comprehensive European research policy. The impact is not known yet, but through studies of researchers involved in the different European research programs it is possible to get a relatively precise idea of the size of this group, and it is possible to discuss the policy initiatives intended to create European networks, and here not least the EU initiatives, which will be in focus at a later session at this workshop.

Nevertheless it is the category defined in 2 comprising the sum of researchers cooperation more or less on an ad hoc basis with European colleagues that is the potential growth level, since they have at least one leg into the European research area (being researcher in Europe) and also some part of their brains (working in projects with other European researchers). Measured in numbers this group is growing and counts more than the group only involved in integrated EU-created networks.

From different surveys we have an idea about the size of this group in Denmark (Kamma Langberg's university researcher study), but the size of this group is not specified for Europe as such.

In addition to the three categories described above we can draw a fourth category, called the international researchers, defined as

4. Researchers from one of the European countries involved in research activity with researchers outside of Europe (defined as the Europe of fifteen members states).

This group can partially overlap with those defined under 2) and 3), but can also be purified to be those working solely with researchers outside EU-15.

The size of the fourth category is hard to find precisely. But generally it is the business sector, which is engaged in such activities as a natural consequence of the fact that the company structures and ownership in many businesses are not kept within the borders of Europe.

The delimitation of what is "Europe" raises in itself some questions, since EU is growing and the conclusion from a seminar looking at cross border and transnational cooperation is that the new Europe is inventing itself in its margins (Jean-Louis Arnaud, May 2002). Europe is no longer just the ten and will in the near future be more than the union of fifteen member states. The figures presented in this paper all refer to EU-15 as of the turn of the century, since that is where the statistical indicators are available.

The incentives for companies preferring cooperation with researchers outside Europe can be several; differences in rules of patenting are just one such reason (known from the medical industry), but such incentives must be analyzed as well since they can influence and eventually hamper the European research integration. Science policy is not only supporting, it can also take form of incentives to stop researchers to go abroad. Internationalization existed among academics long time ago but a good part of the free movement was reduced by WW2, and since then it became more or less a responsibility for the state, the system to activate young researchers to travel. From being a personal responsibility it became a system responsibility, and because the political systems changed in Europe in orientation it became for many US that was the attractive place to study. And still US is the reference point for many scientists and the reference point for much science policy.

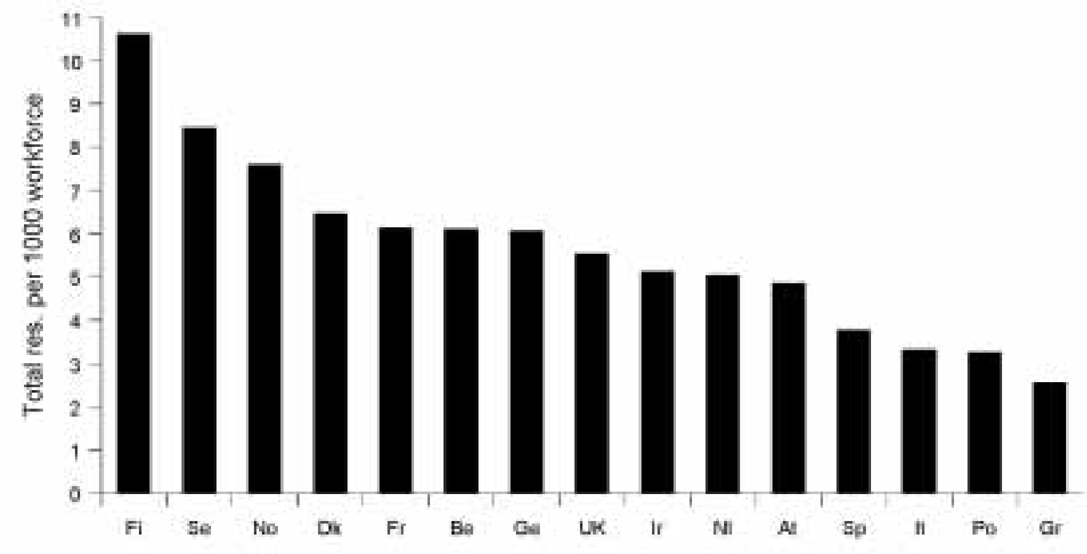
The size of the human capital element of European Research Capacity

The sum of researchers is according to def. No. 1 a pure addition of numbers in the member states, and at the turn of the century the European Union had altogether 1.725 616 researchers (Main Science and Tech. Indicators, 2001/2 table 9). Measured in full time equivalents one third of these come from Germany, France and UK, each having more than 150.000 full time equivalent researchers; while the remaining member states each have 75.000 FTE or less. Researchers from the big European States dominate the European research capacity at the turn of the century.

But what are the dynamics behind this situation?

The relative number of researchers in the workforce is an official Indicator of the Human Resources theme in the Key Figures produced by The European Commission. In many respects, this indicator points to the capacity and the emphasis placed on research, innovation and development in the European Community both Public and Private.

Figure 1: Researchers in the workforce



Source: Benchmarking National R&D Policies, Report from STRATA-ETAN expert working group on Human Resources in RTD, September 2002.

Amongst the EU countries one can broadly detect three to four different groups of countries on the basis of proportion of researchers in the workforce as shown in figure 1.

In the first group we find Sweden and Finland, which have the highest proportion of researchers in their workforce, with levels closer to Japan (9.3%) and to USA (8.1%) than to the European average (5.3%) (Key figures 2001). We also find Norway in this group.

Below these countries, which are outstanding, we can find a second group of member states with levels of researchers above the EU average and in this group we find Denmark, France, Belgium, Germany and UK. The third group consists of Ireland, the Netherlands and Austria close to the average, and then finally we can differentiate a fourth group with Spain, Italy, Portugal and Greece somewhat lower.

How has the development in each of the countries been? And what is the explanation regarding this difference with respect to the human capital level of research capacity within Europe?

Tables 1 and 2 illustrate the trends. These tables reveal wide and growing differences between Europe and its two main competitors, United States and Japan. The proportion of the European workforce engaged in research and development in the areas of science and technology is lower than and/or rising more slowly than Europe's principal competitors.

Table 1. Researchers per workforce and annual growth of the number of researchers

Country	Researchers per 1000 workforce	Average annual growth (%) of researchers
Austria	4.86	7.86
Belgium	6.11	4.59
Denmark	6.46	3.96
France	6.14	1.22
Finland	10.62	12.68
Germany	6.07	1.00
Greece	2.57	6.29
Ireland	5.12	16.51
Italy	3.33	0.34
Netherlands	5.05	4.71
Portugal	3.27	7.61
Spain	3.77	6.79
Sweden	8.44	4.66
United Kingdom	5.54	2.66
EU-15	5.28	*2.89
USA	8.08	**6.21
Japan	9.26	2.57

Note: All data of latest available year. (EU-15 without Luxembourg).
* For 1995-1998; ** for 1995-1997. According to the OECD (2001), the growth rate in the period 1995-1999 was similar in the EU-15 and the USA (about 3% annually).
Data sources: Key Figures 2001 (Eurostat).

Table 1 show that Human resources grew more in USA than in EU-15 as such in the period 1995-1998, but in Europe several countries has shown an annual growth higher than US. Ireland and Finland are extremely remarkable.

Human resources in science and technology grew significantly between 1995 and 1999 in Ireland and Finland more than any other place included in the table. The human resources also grew more than the European mean in southern Europe (with the exception of Italy), so far as Portugal and Austria, Spain and Greece have experienced growth greater than USA in the same period.

The Netherlands, Sweden, Belgium and Denmark have had an annual growth rate bigger than EU as such in the period 1995 to 1998, and while UK has had an annual growth rate lower than EU, it is especially France, Germany and Italy which has experienced an annual growth rate considerably below the rest of EU and lower than Japan.

Table 2: Matrix of national level of human capital and annual average growth rate of human capital (based on Key figures 2001)

Average Annual Growth	Higher than US capacity	Higher than EU-medium capacity	EU-Medium Capacity	Low capacity
Higher than USA	Finland		Ireland Austria	Spain Portugal Greece
Less than USA but higher than EU-15	Sweden	Belgium Denmark	Netherlands	
EU-15			UK	
Low		France Germany		Italy

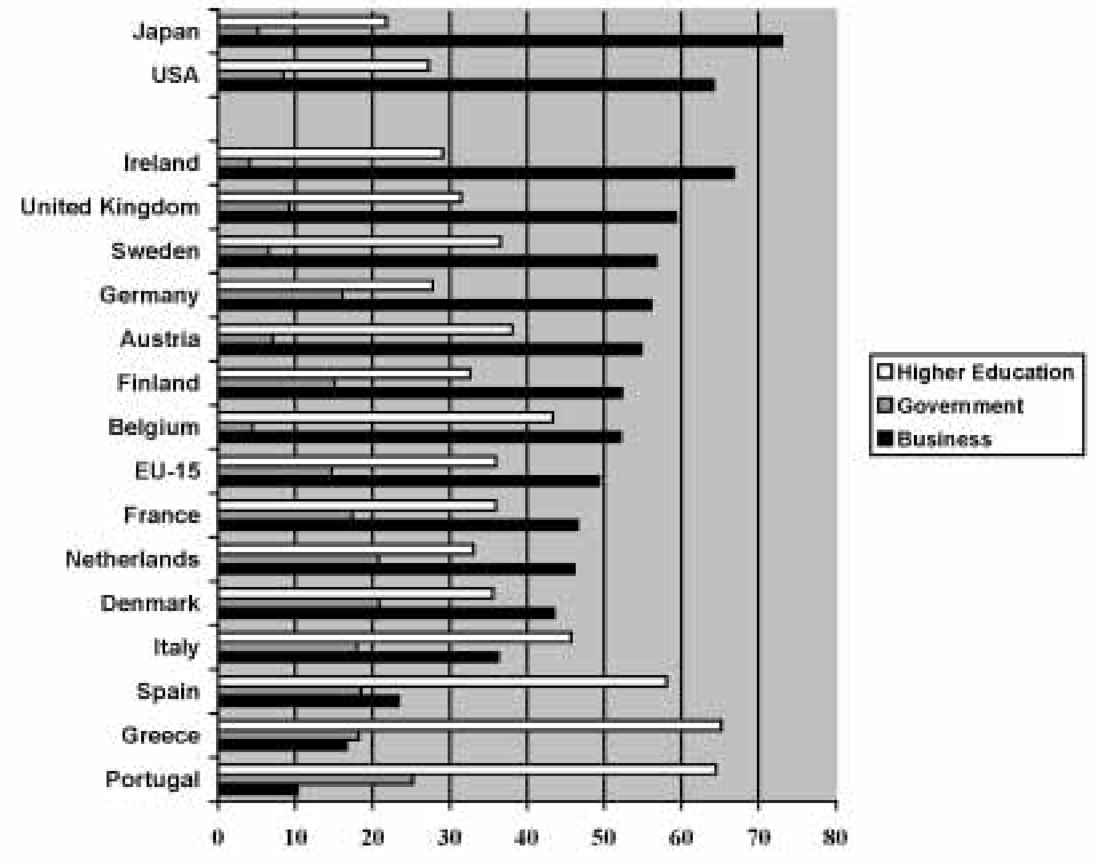
When mixing the national level of human capital with the average annual growth we get a matrix (table 3), which immediately draws attention to Finland as the case with high level and high growth. The high level is a result of high growth and for this reason Finland is an interesting case to study closer. What were the instruments used for building up that capacity? We will return to this question at the end of the presentation.

From a policy perspective the next most interesting cases are those countries that experience a remarkable growth although still at the low level of capacity at the turn of the century, they can be labeled “climbers”. The matrix also draws attention to the potential “sleepers” with low growth rate and medium level of researchers. France and Germany are such cases. As “keepers” we find in this matrix UK, while Belgium and Denmark also are consolidating.

Bearing in mind that Europe had a starting point lower than that in Japan and the USA, there is cause for worry about the capacity for innovation and on a competitive and development scale in some of the bigger European states. The situation in France and Germany might according to table 3 become problematic, when we talk about building European Research Capacity, but Italy is the extreme case with low level and low growth.

Another important question related to Human Capital as an element in European research capacity is in which sectors we find the researchers in Europe?

Figure 2. Researchers per sector (%)



Note: All data of latest available year. (EU-15 without Luxembourg).
Data source: Key Figures 2000 (Eurostat), except USA (NSF).

Figure 2 shows the distribution between the private (business) and (semi-)public (government and higher education) sectors, and research funding in these two sectors for individual Member States. Not surprisingly, there is considerable variation.

The figure shows that in Europe Ireland is the country with the highest proportion of researchers in the business sector, followed by UK, Sweden, Germany and Austria, Finland and Belgium, all having more than 50 Percent of all researchers in the business sector. Ireland has as high a proportion as US in the business sector.

The figure also shows, that countries with low overall participation rates (Greece, Italy, Portugal, Spain) are characterized by a low proportion of research workers in the industrial/business sector. However, this proportion appears to be increasing in these countries.

Investments as an element in building European Research Capacity: Expenditure on R&D

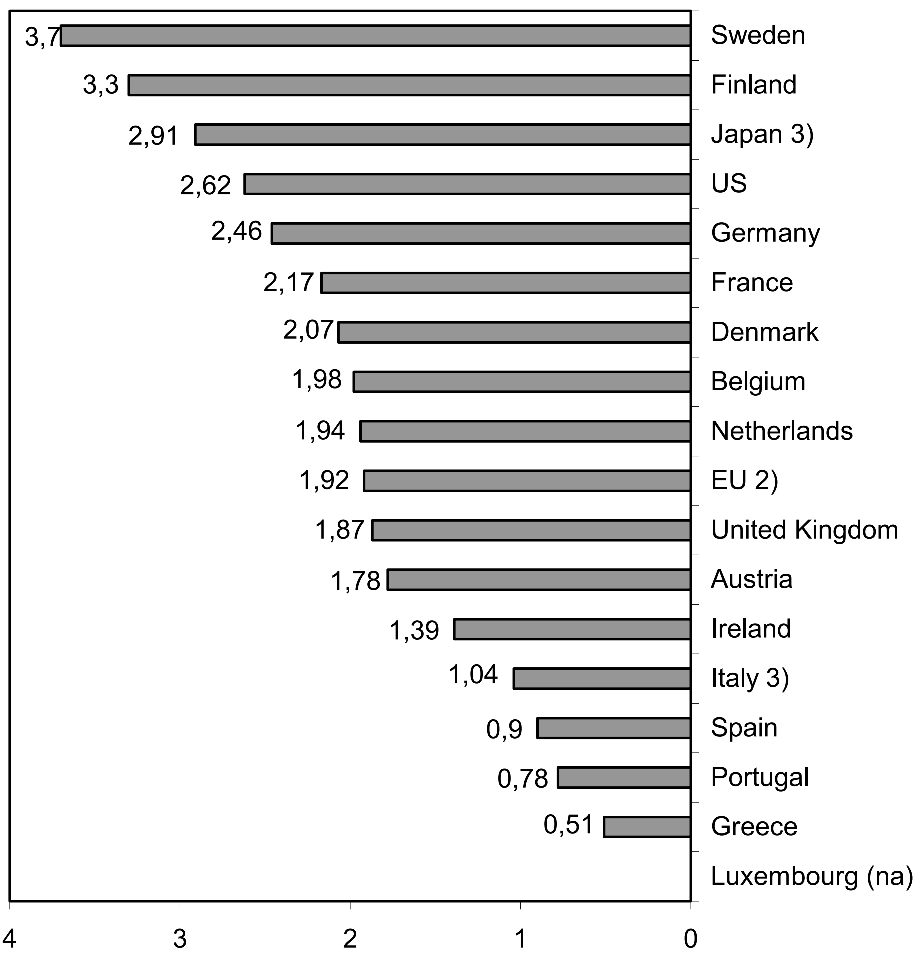
Another important indicator of the efforts to build national research capacity is funds invested in R&D. Figure 3, figure 4 and figure 5 gives information about the use of this instrument.

Europe (EU-15) spent in 2000 1,9 percent of GDP on R&D, while US all the period through the 1990'es have spent between 2.42 and 2.65 and Japan between 2,84 and 3.04 per cent of GDP on R&D (Eurostat yearbook 2002 p. 216).

Funding of research is primarily a national task, but much political attention has been given to the European funding, albeit it is a limited percentage of the total funding of R&D; in most European countries around 4-5 percent of the total amount of money invested in R&D. The interesting issues, that should be pursued is the interplay between the national and the European initiatives. The degree of interplay between these is expected to be extremely interesting.

Measured in investment in R&D in percentage of GDP two of the Nordic countries stand out! Sweden and Finland both have high percentages of researchers in the workforce and as this figure shows they both use above 3 percent of GDP on R&D (fig. 2.1.1 in Key Figures 2001). But can they be used as a representative of a special Scandinavian model? Finland and Sweden are according to the statistics in the Key Figures the only two countries with R&D intensity higher than both US and Japan.

Figure 3: R&D intensity (%), latest available year 1)



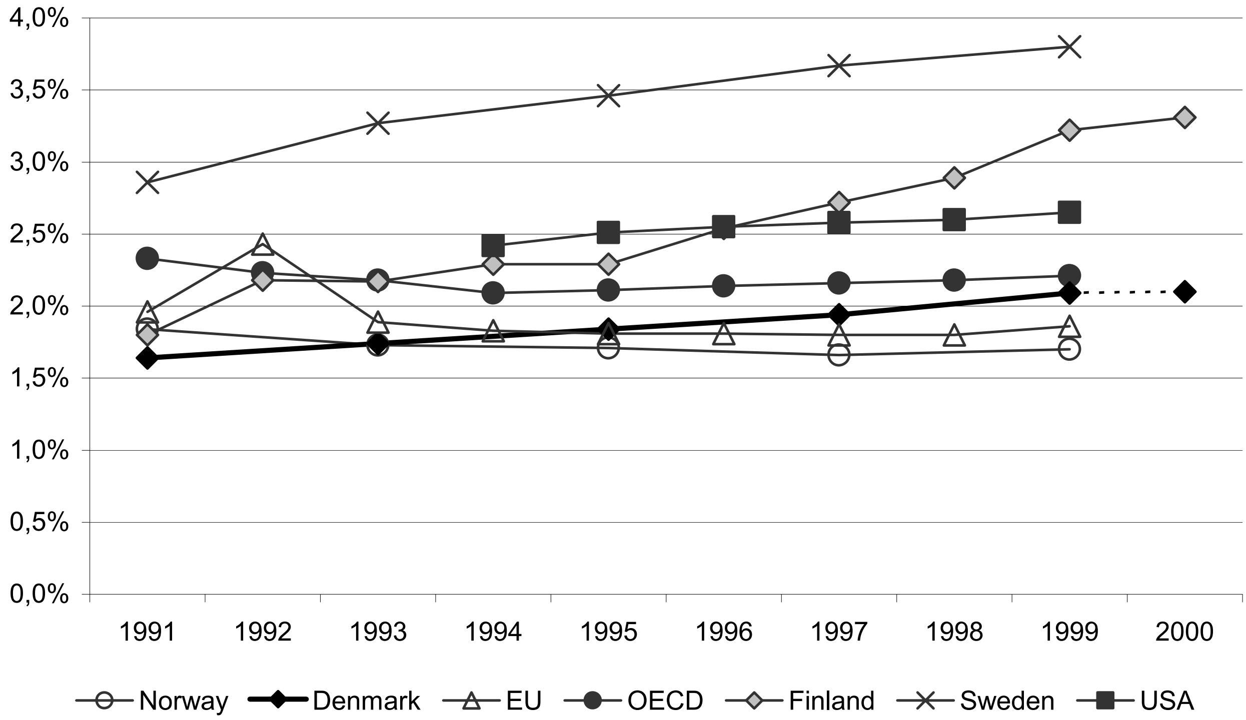
Notes: 1) D, A, P, FIN: 2000; NL, JP: 1998; EL, IRL, S: 1997; all other countries and EU: 1999. 2) L data are not included in the EU average. 3) EU: The EU averages were derived from data received from Member States. Estimates were used to fill gabs in the data.
Data source: DG Research Key figures 2001, figure 2.1.1.

Germany, France, Belgium, The Netherlands together with Denmark spent according to the indicator more than EU as such; UK and Austria were close to the mean, while Ireland, Italy, Spain, Portugal, Greece and Luxembourg spent significantly less.

The growth rate for R&D expenditure (Key figures 2.1.2.) show that Finland, Ireland and Portugal has experienced a remarkable growth rate in expenditure, but also Spain, Belgium and Denmark has shown a growth rate higher than US, while Austria, Greece and Sweden fall in a second category with growth rates higher than Japan, but lower than US. Germany is still higher than EU as such, while France, UK and Italy together with the Netherlands show an average annual growth below the mean for EU. Of the Nordic countries Sweden and Finland are remarkable, while Denmark and Norway show relatively low growth as indicated in figure 4.

One of the questions is again: How has Finland, which already has a high level of R&D intensity, managed to increase this intensity more than in any other countries?

Figure 4: R&D expenditure in percent of GDP in selected Countries 1991-2000



Source: R&D in the Public Sector, Research Statistics 2000, figure 1.3; The Danish institute for Studies in Research and Research Policy.

If we combine the R&D intensities and the growth rates we find a pattern very similar to the one presented in relation to the Human Capital. The results are presented in table 3, where we look for categories of countries.

Table 3: Matrix of national R&D intensity and annual average growth in total investments

	High investment (Intensity higher than US)	**Medium investment**	**Low investment**
High growth	Finland		Portugal Ireland
Medium growth (Growth higher than US)	Sweden	Austria Belgium Denmark Germany	Greece Spain
Low growth (Below EU-15)		Netherlands France UK	Italy

A matrix like the one in table 3 shows again that Finland looks like the single "star" with high level of growth and high intensity.

Sweden has also shown the high intensity and has reached a very high intensity defined as percentage of GDP spent on R&D, but Sweden has not increased its investment into R&D with the same speed as Finland as shown in figure 4. They have had a more stable growth up to a level above the 3 percent goal intended for EU before 2010, but they can be said to "keep a star position".

Some countries, often starting from a lower base, are growing rapidly and significantly and Portugal and Ireland are such examples, which can again be labeled "climbers". Also Spain, Austria, Greece and Belgium have invested with a growth rate higher than US.

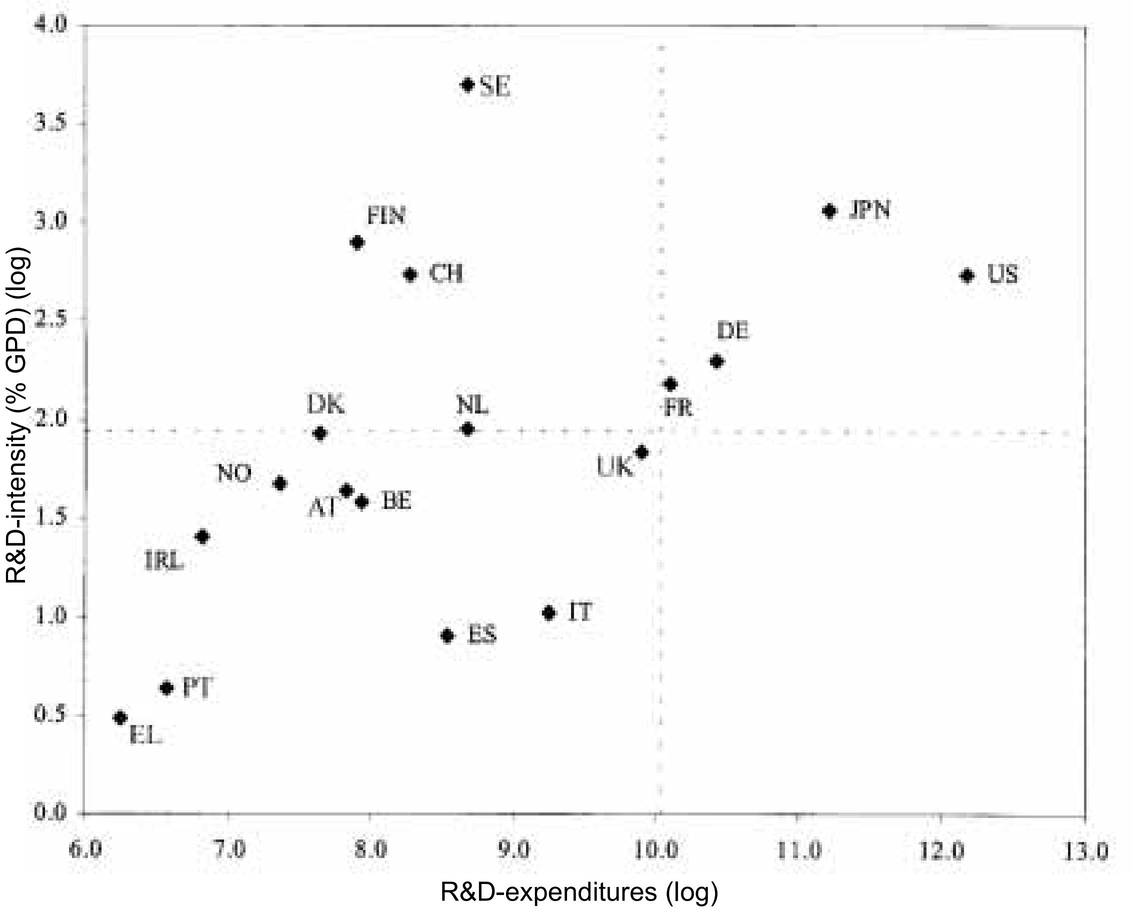
Denmark is very close to the intensity known for EU-15 and can be said to be in a "keeper" position risking being close to "sleeper" position.

Clearly, the overall instrument in building up research capacity is reflected in expenditure on research.

Another way to gain a perspective on this is to review simultaneously the two most important R&D indicators (intensity and total expenditure) as done in figure 5.

There are very alarming growth trends in some of the more developed Member States (France and UK in particular); while others are not impressive. Italy again is problematic since its R&D intensity is low and the average annual growth rate is still below EU level. Figure 5 illustrates this point using all the differences in the statistical figures.

Figure 5: Total R&D-expenditure (logs) and intensity, 1998



Note: The vertical axis shows the R&D-intensity, measured as the ratio of R&D-expenditure to GDP. The horizontal axis shows the natural logarithm of the R&D-expenditure, measured in 1990 US dollars. The dotted lines show the average R&D-intensity resp. log of average R&D-expenditure. For Belgium 1995 data were used, for Switzerland 1996 data and for Greece, Ireland, Norway, Portugal and Sweden 1997 data.
Data: OECD.
Source: Benchmarking National R&D Policies, Draft Report from STRATA-ETAN expert working group on Human Resources in RTD, May 2002. (MERIT).

On the basis of this figure based on economic indicators several groups of countries can be recognized. The first group consists of the large industrial countries (Germany, France, United Kingdom) all trailing the USA and Japan.

A number of medium-sized countries are in the second group (Belgium, Denmark, Ireland, The Netherlands, Norway, Austria).

The third group contains the Southern European countries (Greece, Italy, Portugal, Spain), which look problematic. Finland and Sweden do also in this figure show their deviant status as sparkling stars.

Where are the money spent?

The distribution of researchers on private and public sectors is considered important and likewise it is important to notice how the investments are divided between the main sectors.

Table 4: R&D expenditure (%), breakdown by institutional sector (EU-15 without Luxembourg)

Country	Business Enterprise	Government	Higher Education
Austria	n.a. (40)	n.a.	n.a.
Belgium	72 (66)	3	24
Denmark	63 (58)	16	21
France	56 (54)	18	17
Finland	68 (70)	12	20
Germany	70 (67)	14	16
Greece	26 (24)	24	51
Ireland	74 (64)	7	19
Italy	54 (43)	21	25
Netherlands	54 (50)	19	27
Portugal	25 (21)	31	43
Spain	54 (50)	17	30
Sweden	75 (68)	3	21
United Kingdom	69 (49)	11	20
EU-15	66 (56)	14	20
USA	78 (68)	7	15
Japan	74 (72)	10	16

Data source: R&D expenditure in Europe in 1999 and 2000 (Eurostat).
Numbers in ( ) is the latest published July 2002 by European Commission in a press release.

Table 4 shows R&D expenditure in the different sectors, and the numbers show that in especially in Greece and Portugal, it is the public sector that spends the majority of the total sum spent on R&D, but also in Italy, Spain, The Netherlands the business sector is below EU-15. Denmark is closer to the mean figure for EU, when we talk about R6D expenditure in business. Expenditure on R&D within higher education is extremely high in Greece and Portugal and also in Spain it is more then 50 percent higher than in EU-15.

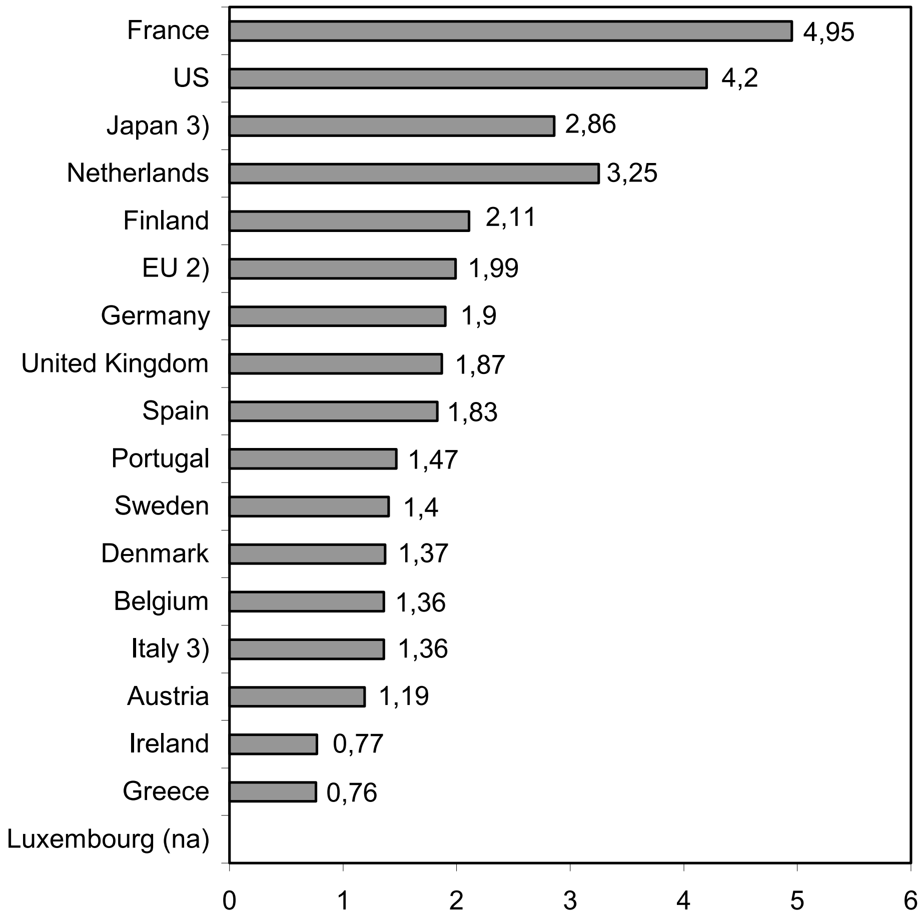
In the group of large industrial countries industry finances two-thirds to three-quarters of research expenditures (Table 4). In most countries, government's role in funding R&D declined over the 1990s. The strongest decrease, between 1995 and 2000 is observed for the United Kingdom, where government R&D expenditure declined by an annual average rate of 5%.

Also in the medium-sized countries of the second group, industry is a large research fonder, but there are marked differences between the various countries (large share of private sector in Ireland, Sweden and Finland; below average in Denmark, Austria and The Netherlands). An important aspect of funding can be seen in the third group (countries of Southern Europe), where government is by far the largest research fonder, especially in Portugal and Greece. So far European money has played a great role in these countries, but it is important that the latter countries continue to foster/encourage private investment in R&D.

Government funding of research

Research has been funded at the national level by basic resources to research institutes plus by external resources, but as a measure of science policy the share of government budget allocated to R&D indicates the relative willingness within a given government to invest in R&D.

Figure 6: Share of government budget allocated to R&D, latest available year [1)]

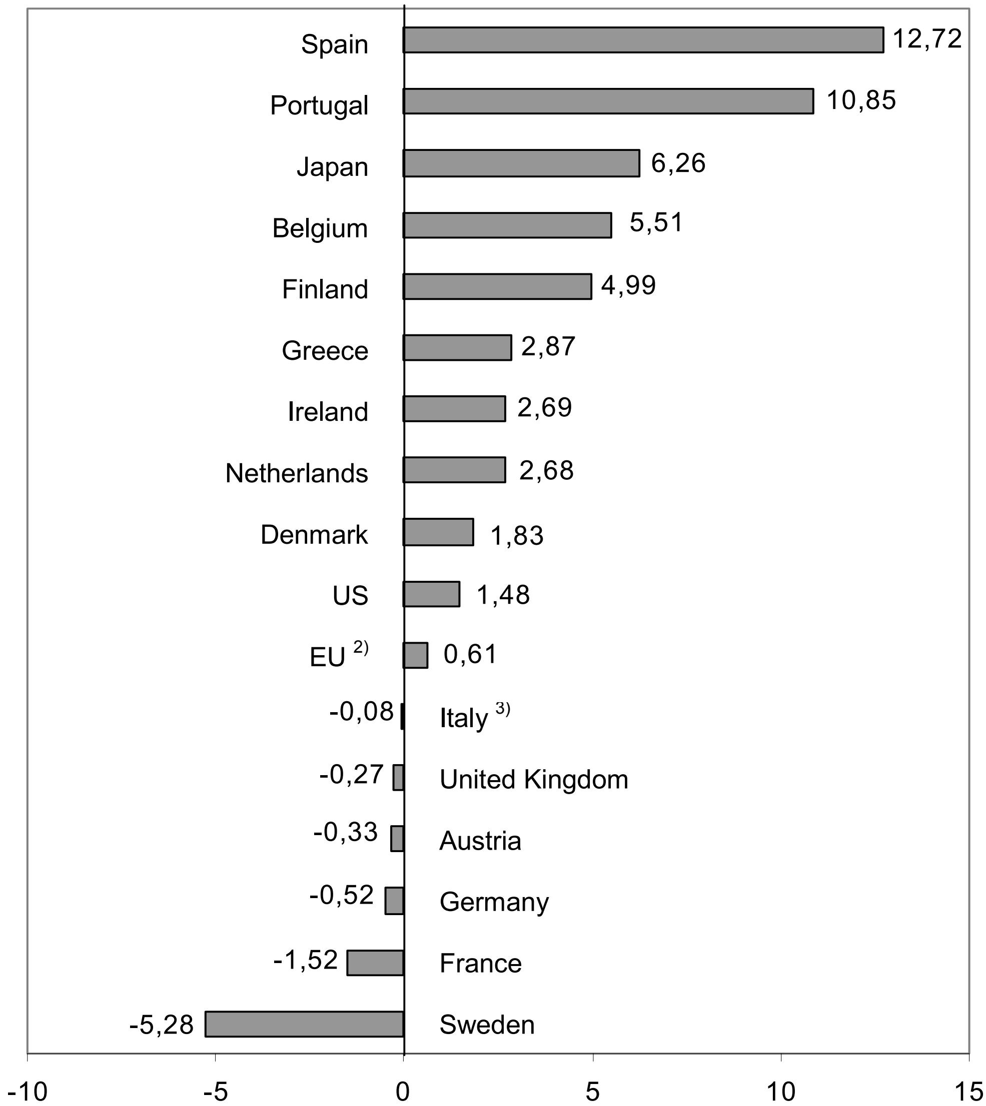


1) B, EL, E, F, IRL; I, UK, US and EU: 1999; all other countries: 2000.
2) L data are not included in the EU average.
3) EU: The EU averages were derived from data received from Member States. Estimates were used to fill gabs in the data.
Source: Key figures 2001, figure 2.3.1, DG Research (GBAORD).

The figures show that France allocates close to 5 percent, which is the highest percentage within EU and a percentage even higher than US and Japan, but these countries are very close to four percent (4.20 for US and 3.86 for Japan). The Netherlands allocate close to 3.25 to R&D while Finland allocated 2.11 percent of the total government budget in 2000 to R&D. The rest of European countries were below the mean for EU as such.

It can be discussed what these figures actually mean in a comparative perspective due to differences between nations in the making of a public budget, but the growth in the figures is for sure expected to indicate some trends in governments' policies towards science, so instead of using the data presented in figure 6 it is actually the data from figure 7, that tells us something about governments' policies towards scientific research.

Figure 7: Government R&D budget – average annual real growth (%), 1995 to latest available year 1)



1) 1995-99:B, EL, E, F, IRL; I, UK, US and EU; all other countries: 1995-2000.
2) L data are not included in the EU average.
3) EU: The EU averages were derived from data received from Member States. Estimates were used to fill gabs in the data.
Source: Key figures 2001, figure 2.3.2, DG Research (GBAORD).

The average annual growth figures show that Spain increased the proportion of the government budget allocated to R&D extremely much and so did Portugal, Japan, Belgium and Finland. (The Spanish figure might be a result of special initiatives in calculating the funding.)

Another problem related to the figures is that the bulk of the public budget allocated to R&D covers only budget appropriations or outlays for R&D, not the actual expenditure, and deviations occur between the appropriated and the actual spending.

We don't know from these figures what share of the government budget that is really available for new active policy, but the measure is the best so far indicating governments' science policy, and it is very much related to the research capacity, since the majority of the budget is usually spent on salaries of public sector researchers and on running of the public sector research institutes and in this way it measures the government funded research capacity.

A more detailed discussion of public and private investments in R&D are presented in the report on this issue within the project “benchmarking of national policies” (Benchmarking of national policies: Public and private investments in R&D”, Final report from Expert Group, June 2002).

Additional instruments for building research capacity

There are other important indicators of research capacity than just the number and distribution of researchers and the size and distribution of R&D investments. A number of these issues, such as education and training of researchers, building of research facilities, infrastructure, programmes etc. will be addressed briefly below. They are all important elements in the science policy aims of building research capacity.

Within the EU project Benchmarking National R&D Policies a STRATA-ETAN expert working group produced in spring 2002 a report on Human Resources in RTD (to be seen on the CIRCA net). In this report we find several analysis containing relevant information for the issue: ”building European research capacity”. The Expert Group highlights in its pipeline model the necessity to include issues broader than those narrowly associated with building research capacity in the short run.

Educational aspects

The STRATA-ETAN group emphasizes the need to look at basic training in schools, undergraduate enrolment as well as postgraduate studies; all relevant steps for building up research capacity, since training for scientific research is a continuous process requiring the construction of substantial knowledge as well as the acquisition of analytical and deductive skills, not to forget the creation of interest in science (Report form STRATA- ETAN expert working group on Human Resources in RTD, May 2002). The educational aspect has to be measured in more than investments, and in particular investments in PhD’s are extremely relevant.

Doctoral Training
The prevailing picture of doctoral training is that of a slow increase in numbers and proportions throughout the 1990's in most European Countries, but not in all. Again Finland and Sweden show significant growth. There appears to be a correlation between PhD production, investment in PhD programmes and PhDs in the workforce, with Finland and Sweden as prime examples. In Sweden the initiative to build up Ph.D.’s were taken very early and in a university reform from 1969 professors were told to concentrate on the training of Ph.D.’s. Finnish initiatives came later, but there are now 108 PhD-schools in Finland, and the results are visible in table 5 (www.minedu.fin/uvm/nyheter/2001).

Table 5: Total new science and technology PhDs per 1000 population aged 25 - 34 years

Country	1995	1996	1997	1998	1999
Belgium	0.37	0.38	0.38	0.38	0.36
Denmark	0,49	0.42	0.53	0.53	0.56
Germany	0.61	0.64	0.68	0.72	0.75
Spain	NA	NA	NA	NA	0.43
France	NA	NA	0.77	0.71	0.71
Ireland	0.41	0.55	0.55	NA	NA
Italy *	0.13	0.13	0.13	0.11	0.14
Netherlands	0.36	0.38	0.36	0.36	0.35
Austria	0.44	0.50	0.58	0.55	0.56
Portugal	0.19	0.23	0.21	0.21	0.23
Finland	0.60	0.55	0.61	0.99	0.97
Sweden	0.88	0.99	1.04	1.08	1.17
United Kingdom	NA	0.54	0.63	0.73	0.78

* Italy: derived from data not yet approved or amended by the Italian Statistical Office.
NA = not available as yet
Source: Benchmarking National R&D Policies, Report from STRATA-ETAN expert working group on Human Resources in RTD, September 2002.

First Destinations and Post-Doctoral Training

Much of the research effort in the public sector is shouldered by post-doctoral fellows, almost always on short-term contracts. Recently, as a consequence of the fact that post-doctoral opportunities seen as leading to less attractive career paths, there appears to be a reduction of the supply of talent at this stage, with overall negative consequences, particularly for public research. For newly qualified PhDs, the loss to bonafide scientific research can be as high as 40%. A small percentage (5%) go overseas and do not return in the short to medium-term. For some Member States, this adds up to a wasteful "brain drain" - both to other occupations and to other countries (Report form STRATA- ETAN expert working group on Human Resources in RTD, September 2002).

Appeal and attractiveness of science and technology to youngsters is especially mentioned by the Expert Group as a relevant aspect partly resulting from media coverage but also from school and other forms of socialization. In some countries the government and/or the educational institutions run special Public Relation-programmes to increase general interest in science and technology. Such initiatives have been used in Scandinavia.

The educational perspective is of great relevance, but education is not enough; if there are no jobs to get; if there is no funding of research, then you can eventually be trained but never go into action in a job as researcher, and therefore there is an interest in what is the first destination for a young researcher after training? What are the career options? In this presentation that issue is not on the agenda, but the question is central. How have the career options changed over time in Scandinavia? And how has it changed in the rest of Europe?

Building of research facilities

The general support to universities is a basic element in the building of research capacity, since the greatest part of researcher training and education is given by universities, if not done within the private business sector, within industry. The costs covering building of research facilities are included in the R&D expenditure data.

The establishment of special laboratories or centers is part of the figure mentioned above. As an instrument it is increasingly used in Scandinavia, but the general impact is hard to measure, and often such centers are organized for a limited time period.

Building research facilities, setting up laboratories, is primarily a national task. How much has been allocated to building research facilities in Europe over the years?
Here it is not enough to use the overall figures for expenditure? The trends as described in table 4 show that private initiatives play a great role in building research facilities.

In recent years there has been several public or semipublic initiatives regarding European laboratories, and some of the presentations at MUSCIPOLI workshop 2 referred also to institutions with a purpose of creating European oriented researchers albeit the topic for that workshop was inter- or multidisciplinarity. The French initiative "La Maison des Science de l'Homme" is one such example (see Hinnerk Bruhns et al. in MUSCIPOLI workshop 2 report).

Policies for international mobility and international cooperation

Programmes, for instance mobility support programmes by EU, have had the clear intention to increase European integrated research, and mobility is still an instrument included in the 6th Framework Programme. (See "A Mobility strategy for the European research area" from 20.06.2001.)

Researchers' mobility has not only been an issue for EU but also at the national level. In many research councils it has been a more or less obligatory demand of a project proposal that it had to include cooperation with researchers from another country, and for PhD.-programmes the mobility aspects has also been an integrated part, albeit not in all countries, and not by all councils (depending of science field).

Requests to project proposal in form of applications to national research councils have been related to international mobility and/or international research cooperation as such and not for specific European mobility/cooperation.

Special programmes for attracting foreign researchers can be seen as an instrument used for building up the European research area defined as in the third definition and fourth definition, and if they stay they will increase the European capacity as a sum.

International cooperation within the business sector often shows division of labor, with research concentrated in some parts of the company; this kind of international labor division is increasingly found within big companies.

Use of tax instruments

Different forms of tax related instruments have been applied in order to increase the inflow of foreign researchers (Technopolis has collected data about this issue).

Tax reductions for investments in research are used in many countries and recently introduced in Denmark for business sector investment in public research, but so far no special reduction for investment in European research (In Denmark a special initiative was introduced in 2002 with 150 % in tax reduction for private-public research cooperation, but so far very few have indicated interest since the rules for access to this instrument is very strict and based on research Councils evaluations of the research projects) (OECD has undertaking a special study of use of tax instruments).

Use of institutional arrangement

Centers of Excellence is a special way of building up research groups and research institutes with or without walls. Initiatives to Centers of Excellence were in Europe taken by The European Science Foundation in the end of the 1980'es, inspired by US. Now it is an instrument being part of the 6th Framework Programme, while "exploring research" has the new instrument on the European Science Foundation's agenda in their support to building European research capacity. A report describing joint European research centers and their role in building The European Research Area has just been published by the Commission (Report EUR 20245).

Centers of excellence have also been used as an instrument at national level, see for instance the Norwegian research Councils announcement of 13 new centers becoming status as Centers of Excellence (www.forskningsradet.no 19.6. 2002) and in Denmark the socalled "Grundforskningscentre" are to be considered as centers of excellence ("Centres of Excellence I 10 år", October 2002)

A variety of EU programmes

The Framework programmes being the most significant part of this European activity within science policy appealing to a variety of European researchers. More orientation about the Framework programmes will be presented at the workshop by representatives from DG Research. The interesting aspect when focusing on the national activities is the degree to which the national policies have been organized parallel to the European when it comes to themes for research. A closer study of the national interplay with the European agenda would be extremely relevant and this theme could be object for a new network.

Establishing European research identity

The establishment of European Research Societies or Associations has been an issue that is part of an ongoing activity with the intention of creating a European identity among researchers (This issue has been on the agenda at several European meetings among researchers, i.e. in Lyon, fall of 2000).

Establishing European Research Councils is another potential instrument. This issue was on the agenda for a conference organized by the Danish research Councils during the Danish Presidency September 2002 and the issue is on the agenda for The European Science Foundations November 2002 meeting.

Infrastructure

The research structures in the European countries do vary, but the variations are greater, at least expected to be greater when we compare EU-15 to the surrounding countries, to the new member states. But also inside EU there are relatively big differences for example in the amount of research associated to the defense industry/weapons etc. (see “Trends in Science Policy” chapter from MUSCIPOLI report nr. 1.)

Research infrastructure can be defined as the ways research cooperation is facilitated. How well developed is the infrastructure within a given country and how well developed is the infrastructure across Europe. Mediating research from universities to the business sector is a challenge. Big companies have researchers themselves able to read and understand scientific reports, while that is a problem for smaller companies having an absorption problem (Ebbe Graversen, 2002). The interaction between universities and private companies has been strengthened by the use of adjunct professor, an initiative used with success in the Nordic countries.

Cooperation with business

All over Europe the private business sector finances a great part of the total investment in R&D; in most countries it is the majority of R&D being financed by the private sector, and the majority of researchers are working in the private sector.

The industrial structure varies across Europe, and for the interaction between science policy and the industry this aspect is an extremely important issue. It is my hope that more analyses of this issue can uncover the uncertainty in this interaction.

Technology brokerage is a relatively new concept, but many initiatives have been taken to increase the exchange of innovations and more are under way.

Summary of R&D capacity indicators

Finland and Sweden are clearly exceptional on the score-boards both in terms of human capital and investments. Only Finland and Sweden show relative research efforts comparable to the USA and Japan, and they are also the EU countries with the greatest percentage of the workforce involved in R&D.

Overall, the R&D intensity values have not changed much from one year to the next, but in the period 1995-2000 increases are noticeable in Finland, Belgium, Denmark and Austria. Later figures for Denmark have shown a falling trend, albeit political promises to support the building of research capacity are heard.

Private-sector investment in general is increasing slowly in the European Union, but still is considerably lower than and being outpaced by the USA and Japan. Private-sector investment is an important element and has a particularly critical role in research activity in the less well-established Member States.

The most recent data show that the business sector provided more than 60% of domestic R&D funding in OECD countries, a slight increase from 1990. In the EU, the share of R&D expenditure at constant prices of business enterprises was 66% in 2000 (63% in 1995). Finland and Sweden are both above the EU-average. In the United States business enterprises accounted for 78% of R&D expenditure in1999, and in Japan for 74% (Table 3).

Public-sector investment continues to be an important driver of new research activity, particularly in those Member States with low to modest industrial investment. But there is evidence of public-sector underfunding in the more scientifically developed Member States, leading to stagnation or even decline in public-sector productivity.

When it comes to the additional instruments the indicators are rather limited. Only the educational aspects are covered, and also here Finland and Sweden are scoring very high in terms of PhD-training.

We need more information about the use of instruments before we can reach a situation where there is no uncertainty about the instruments, but more data can be collected albeit there do not exist statistical indicators for all the relevant instruments.

Uncertainty is associated to the impact of the instruments, since the impact naturally varies with the strength of the instruments, for instance how much money is in a given country allocated to a specific instrument, not just money allocated to R&D?

How far can we go into a general conclusion of impact of different instruments? This issue will be up for discussion at later sessions of this workshop.

Do we have different regional models in the building of research capacity?

This summary leads back to the initial question: can the patterns in the building of research capacity be described through a number of regional models? In the data presented above there is a kind of grouping of countries, but the grouping does not totally follow a regional model, although some trends do.

One of the conclusions that come to mind when we look at the pictures presented by the figures is, that countries are in different stages - even within the fifteen members of the European Union. Some can be labeled *stars*, some can be labeled *climbers*, and some can be labeled *sleepers* stagnating at various levels. These clusters to some degree support a regional model, but the variations within the regions lead to a model more focusing on the “period” for a given series of countries.

The *Stars* is the label we can put on Finland and on Sweden.

The *Sleepers* is a label that can cover several of the big industrial countries relying on their research capacity and having low growth rates i.e. not building anymore. Others are *keepers* defined by having a medium capacity and growth rate at EU-15 or above, but without specific dynamic trends. Belgium and Denmark are examples of such countries.

The Climbers is a label that can be used for those countries building up from a low level showing remarkable growth rates. Climbers are found in southern Europe but definitely also in other places in Europe. Ireland and Austria have shown such dynamic trends.

Finland and Sweden stands out as excellent examples based on figures shown. They are outstanding if we look at the percentage of GDP spent on R&D. Finland is close to three percent while Sweden is close to 4 percent. But can we talk about a Nordic model? Yes and no! There are some likenesses, but also differences within the Nordic countries, and specially Denmark are in some respects quite far from the Finnish and Swedish model, and so is Norway the country traditionally included in Scandinavia.

Both these countries do not show the same patterns as Finland and Sweden. Denmark has been following an upward trend albeit at a lower level through the 1990’s and recently reducing the upward curve while Norway measured in percentage of GDP is relatively stable below the other Nordic countries, so using these indicators we cannot talk about a Nordic model for building up European research capacity, unless we use other types of indicators than the economic ones.

If there is a best practice among the science policy instruments used across Europe, then we will have to find it in either Sweden or in Finland. Ireland too is an interesting example due to the growth rate found there very much found in/depending of the business sector.

Those countries that do not show the same increase in capacity building as Finland and Sweden, those having a deviant pattern like a falling trend: can we conclude that it is a result of a national science policy, being no policy or just a non-efficient policy? Or are there structural barriers for positive impact of the policy initiatives? Among the big industrial countries there exist differences in culture, as well as differences in the structure and background of the established research capacity. The dynamic aspect of ongoing building of research capacity is not only dependent on the strengths of the economic instrument! Those countries we can define as capacity builders or even *climbers* are extremely interesting, defined as countries where there is considerable growth and policy initiatives supporting the growth.

A closer look at the interplay between capacity and the policy instruments used at the national level could be a topic for further study; some steps are taken within the STRATA-ETAN project: "Benchmarking national research policies".

Key success factors - a summary of Finnish science policy

Finland is the country most often referred to as outstanding in the dynamics of building research capacity, so it is central to look for the explanation of the success.

In the Finnish case it is argued that political consensus on science and technology policy means a lot. Well functioning systems of planning, decision making as well as close cooperation between different actors are contextual instruments of great importance. Unfortunately these factors like several of those mentioned below are outside what the usual indicators can tell.

1. Political consensus on science and technology policy (in the Science and Technology Policy Council chaired by the Prime Minister).
2. Well functioning system of planning, decision-making and funding for research.
3. Large amount and rapid growth of R & D investments in last 15 years.
4. High level information technology infrastructure.
5. Active research co-operation in the country and within the EU.
6. Co-operation in researcher training between universities and to some extent also with companies.
7. Large investments in education and a full regional coverage by the university system.
8. Highly educated young people and motivated students both at the graduate and the undergraduate level.
9. Wide range of high-quality education in engineering.
10. Well-qualified teachers.
11. Focusing on the quality of scientific research.
12. Profitability of R & D investments (e. g. patents).
13. Close co-operation between the different actors (ministries, science and technology funders, universities and research institutes) in the public and private sector and between sectors in research.
14. Active internationalization.

Finland has recently published a strategy for its role in the creation of ERA. The strategy can be found at www.aka.fi/

The success story of the star in this story, Finland, raises our awareness of the field in which Finland expanded more than any other European country, the IT sector. Will the changes in the economic forecasts for the IT sector, eventually turn Finland into a falling star? The risk exists for all countries which are highly dependent of one field of research!

Can we reduce uncertainty on building research capacity?
Can we learn from the Finnish performance in building research capacity?
Yes we can learn, but can we do the same? And will it reduce uncertainty?

At least it reminds us that in addition to the elements analyzed above we should also discuss the composition of the European research capacity: who is trained for doing what kind of research?

That question relates to strategies for the future of Europe!
The selection of specific scientific fields might be an issue worth discussion: Which are the fields that shall be promoted among young students? Science defined as natural science, medical science and technology now including biotechnology in addition to IT has in recent years been perceived as the most promising research capacity to build up when your final goal is economic growth.

Other ways to build research capacity than the above mentioned

In addition to the structural initiatives, the issue of management is on the agenda. More dynamic research management can increase the output of a given research capacity. In many European countries this is seen as the road to increase the outcome of research.

Greater linkages between private and public R&D is included in the European policy advices. Linkages exist between many big companies and public research institutions, but an increase in the flow can come from better contact and exchange between small and medium business and public research institutions.
How can policies regarding this interaction be developed? The instruments are numerous, but will they work in any context? At the present time the government in Denmark is trying to find a model for managing universities with the special intention of increasing the interaction between the public R&D sector and the private business sector, especially looking at the flow from universities to business. Professional managers are one of the instruments intended.

Headings for the discussion of the workshop

Managing with uncertainty in science policy, that is the topic in the MUSCIPOLI project.

Can science policy reduce the uncertainty? By using specific instruments, known to be efficient based on experiences from other countries. Will managing then be easier? Yes! If the impact of the instruments is known!

What has been the impact of the different European initiatives regarding building up research capacity?

It is clear that there are cultural differences framing the way research training and institutional structures are built. And the member states come from different levels of intensity of R&D.

As concluded by the expert group looking at human resources several of the bigger European countries are falling behind, while smaller countries are climbing up the ladder, measured as percentage of GDP spent on investments in R&D. One of the reasons is that several of the big countries are relying on a relative big mass of researchers, and relying on business financing and therefore not feeling the need for extra efforts, this again being a support for the “period model”, characterizing them as “sleepers” at various levels more than for “regional models”!

We can discuss whether Europe described within the so-called “period model” will end up with the same clusters as the “regional model”? My argument is that it will not, albeit the group of Southern European states shows some likeness, and some of the Nordic show likenesses.

The “regional models” have something many studying this issue find extremely relevant, not the least the cultural aspect, which has highly influenced the educational system. But cultural inspirations are not always limited to the region to which you belong! Denmark has in many ways followed the German model in our university education and researcher training, but gradually Denmark is on its way to the American model for higher education and researcher training, a model, which has highly inspired the Swedish and the Finnish system.

Denmark introduced the Ph.D.-system relatively late, but has recently increased focus on the training of Ph.D.’s and has introduced research schools. In contrast to Denmark Sweden has a long tradition for research training schools (introduced in the beginning of the 1970’s) and have had a higher production of Ph.D.’s. That and a general political will is the explanation of the Swedish success story, making Sweden a prime example of “best practice” science policy? In Finland the amount of Ph.D.’s is also an explanatory driving factor. Data show that Finland started rather late with PhD’s but expanded significantly as an element in their general educational policy for building up research capacity. Today Finland has a very large number of PhD-schools. And Finland must generally be seen as “the star” since Finland managed building so much within relatively short time due to political will and investments.

Barriers

The training and efficient deployment of Human Resources for RTD is affected by a number of barriers of variable invisibility.

The crucial point if the potential is there might be the entrance to research training, is it killing for the innovative students? That was one of the issues raised by the European expert group, and in addition the expert group commented on three additional barriers - gender, financial considerations and culture. Women working in research represent only between one-quarter and one-third of R&D staff in the Member States and the gender imbalance gets more serious with increasing rank in the hierarchy. How much has the role of women in science influenced the capacity building?

Finally then culture as a barrier; we know there are cultural differences, but we also believe that they are diminishing. The EU member states will be more alike over time, but it takes time.

What can be done to increase European research capacity (and to reduce uncertainty in science policy)

The original issue was: Can we talk about different models based on regional closeness? Or are all countries in Europe using the same instruments? All might be using the same instruments, but with different intensity and in different national contexts.

Education and training is necessary and money to support research is necessary too, but without training money is not enough. Building European Research Area requires investments along a pipeline, not only investments in research.

The financial considerations are complex when it come to financing research capacity, and it is an interplay between public and private money, but investments are necessary and especially necessary to build up.

An integrated policy is necessary if success shall be achieved. Planning and long-term perspective is necessary. That more than any thing ells will reduce uncertainty.

Interaction and good contacts between the different actors is extremely relevant. Cooperation between business and public sector will increase the efficiency of the instruments.

Building European Research Area is a much more special project than just building European research capacity, but without European research capacity it is impossible to build the European Research Area!

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2.2 Conclusions from the Thematic Evaluation on RTDI expenditure by the Structural Funds,

CIRCA-Report presented to the European Commission, 2000

Introduction

Our conclusions and recommendations are presented thematically, under the six themes originally identified for the study.

The technology policy option for regional development, which is being provided by the Funds, is inducing fundamental long-term changes in the development capabilities of the regions. In addition, the Funds are changing the culture of regional development and providing new tools for regional actors. Innovation and technology development are now on the policy agendas of many regions, for the first time.

Many of these regions are still trying to understand the dynamics of these new tools, to find appropriate institutional designs and management systems. Training, exchange of experience and learning opportunities will have to be improved. So too will real time monitoring and evaluation of best practices.

Regions may be seen to over-invest, under-invest or mis-invest in technology. Determining the most appropriate strategy for a region is not an easy task. This is mainly because the determinants are not only the general guidelines and national priorities, but also the regional specificities, path dependencies and parameters related to political and administrative strengths and the power relations of the region, as well as the need to adapt strategies to new environments and circumstances.

Growth and employment, the ultimate goals of regional development policy, appear either when there are very important physical endowments (mostly independent of technology policy) or when technology policy is conceived and implemented in a way that triggers external economies. In other words, technology can help to modernise productive structure and make them more competitive, but, for these regions, it is not a target, *per se*.

The evidence of two rounds of Structural Funds investment in RTD is beginning to show that investing more in technology is not necessarily the right way to tackle the 'technology gap' problem. Rather, more emphasis needs to be placed on the systemic features and linkages between technology, innovation and knowledge.

Capacity enhancement - RTDI Infrastructure

The need for improvement of public RTD infrastructure in the Objective 1 and Objective 6 regions continues to be significant, especially in regard to training and human capital enhancement. But, more consideration must in future be given to the demand (and not just public sector demand) for such infrastructure. Demand anticipation is important, especially for the fast growing regions (a minority), but moving too far ahead of demand brings a risk of inefficiencies and underutilised capacities. While regional requirements and specificities will determine how quickly and in what direction a particular region might go, in upgrading its public RTDI infrastructure, the important consideration is the extent to which utilisation of capacity, driven primarily by the productive sector, may be expected. The need for enhancement of public RTDI capabilities in LFRs is certainly real and is recognised, but the timing of this expansion must be brought more into line with the expected demand and with utilisation potential. In future, proposals for additions to RTDI infrastructures must be subjected to more testing demand and utilisation criteria. It should be a matter for the proposers to produce such evidence, including business plans, milestones and evaluation indicators.

This is a particular case where the Community added value in terms of transferring knowledge about similar successes and failures can be important.

Where the market conditions are rapidly expanding, capacity bottlenecks can be expected, as in Ireland, for example. In such conditions, anticipation of likely demand for additional public sector capacity is essential. But in others, where private sector demand is stagnant, there ought to be a requirement for regions and Member States to demonstrate how regional demand is to be mobilised and later on, to report on the extent to which these new facilities are being utilised by the enterprise sector.

Table 1: Summary – Community Added Value Impacts of the Funds

Short Term Impacts	Medium Term Impacts	Longer Term Impacts
Criteria: Enhancement Cohesion (S&T)	Criteria: Catalytic Innovation Integration	Criteria: Cohesion (Economic & Social)
Results: Some RTD convergence. Strong on enhancement criterion - but mainly public sector supply. High additionality - on public sector side.	Results: Good results on the catalytic criterion, especially on regional RTDI policy and planning. Some evidence of innovation in policies and programmes. Improvements in communications between agencies/actors and better integration of programmes still needed.	Results: Some economic and social convergence at the European level. Regional disparities continue to be a major problem. How to embed RTD into regional economies is still a major challenge.

At the present time in the majority of cases, the Funds are:

- Widening the disparities between the public capacity to supply RTD and the demand from enterprise in LFRs for it. While there are positive aspects in enhancing capacity and improving quality, it is on the other hand clear that in such cases the successful research laboratories gain momentum and are more interested in co-operation with other research centres or companies outside the Objective 1/6 regions. Consequently, improving supply side capabilities may harm rather than benefit locally embedded technology transfer. The public research enterprise is enabled to survive without taking the needs of the local economy into account.
- Strengthening public RTD capabilities for which there is little use and which are of little relevance to the actual needs of industry, mainly small and micro enterprises, in LFRs. This is not intended to mean that RTD capabilities should remain underdeveloped, but that there is a need to adopt plans that will ensure at least to some degree, their local role.
- Creating future obligations in respect of the running costs of these public facilities and programmes, which will have to continue to be met from public funds.

A change in the approach is required. In the majority of cases, the 'innovation gap' should become the key consideration and regions need to be encouraged and facilitated (where necessary) to develop region-specific innovation policies and strategies, which may, of course, include support for research and technology. The quality of the underlying regional strategies for RTDI is a major weakness to be addressed by all participating regions in the next round of the Funds. In this context, the RTP exercise has provided a commendable model for consideration.

Conclusion (i):
Capacity enhancement has been important for its contribution to the development of human capital and skills. Although better than the first period, capacity enhancement has still been overemphasised during this period of the Funds. Greater attention now needs to be given to making and effective utilisation by enterprise of the existing installed RTD capacity in the Objective 1 and 6 regions.

Recommendations:

- Utilisation by the enterprise sector of the existing RTD capacity must become the main priority under this theme for the majority of regions in the future.
- There is an argument in favour of strengthening RTD capacity in the fast growing regions, Ireland, for example. In such cases demand has to be anticipated, otherwise bottlenecks in skills and expertise will slow development. But this process must be demand driven. The criteria to be tested in judging capacity enhancement proposals are 'anticipated demand' and 'utilisation potential'.
- With very few exceptions, the major science and technology park infrastructures (but not smaller scale investments like incubators) have been very problematic. There are a few success stories and these should continue to receive support, but additional investment in major facilities of this type should be curtailed. Rather than supporting real estate development, using incubators, or building gradually in areas where there is a likely growth of inward investment (transnational as in the case of Ireland, or transregional as in Castilla Y Leon) are the only instances where careful planning can result in positive economic effects.

Conclusion (ii)
'Linear type' indicators – capacity enhancement, absorption, technology gaps etc. – have been overemphasised.

Recommendations:

- More attention is needed to the performance of regional innovation systems and to the restructuring of these systems. The regional strategic planning process is a correct approach in this direction. The regional planning initiatives (RTP, RIS, RITTS) of DGXVI and DGXIII are good exemplars.
- Where support for research is requested in future, it should be justified on the basis of improving the quality of research performance, the quantity and quality of graduate training and human capital and on spillovers and externalities, rather than on the direct benefits associated with the acquisition of research knowledge. The multiplier effects of technology policy come first from externalities.
- A shift in the approach to support for research at universities might be considered. This new approach could be more strategic. Universities would be invited to prepare strategies for the longer term development of their research capabilities (in addition to the usual peer based project funding), and be supported on the quality of these strategies. New schemes for university funding along these lines are being introduced in Ireland, for example. This approach requires effective collaboration between the Research and Education Ministries, which was found to be the exception rather than the rule.

Innovation and technology transfer

While the demand from industry for the various schemes in operation is high, often they are in "overbooking", it is nonetheless difficult to see yet, significant industrial impacts from the Funds. On the contrary, many interviewees have been prepared to say that industrial impacts are "barely discernible", even "minor". Certainly, the general perception of the impact of these programmes on industry is not reassuring. Spillovers and externalities stemming from the investments made in RTD have been limited. In the majority of cases one has to assume that the major benefit was the effect on training and skills and on human resource enhancement.

At this stage, it is apparent that linking technology to production continues to be a major problem, if not the most important one. To a large extent, penetration and utilisation are the underlying weaknesses, as they were in the 1989/93 round of the Funds. The PEDIP programme in Portugal, for example, has managed to involve no more than 100 firms in its industrial innovation action. In Merseyside, no more than 10% of SMEs in the region have been reached by RTDI initiatives. The 'industrial reach' of most actions under the Funds is short, considering the population of SMEs needing assistance. Although it is clear that increasing the number of assisted companies is not an easy task, as even experience from core regions proves, this data suggests that alternative, more ambitious ways of support need to be explored.

It may be that the conventional project by project approach is less appropriate and that a broader and more integrated support programme for the total strategy of the firm, needs to be developed. In this context, the examples of CDTI in Spain and Enterprise Ireland in Ireland provide useful models. The Portuguese authorities are considering a scheme which would support a percentage of the total R&D payroll of the selected firm over a period for an agreed programme of research. Approaches like these may be more promising than conventional project by project funding.

While the situation has improved, Portugal, Southern Italy, Spain and Greece are still confronted with major bottlenecks in regard to penetrating industry and in securing a greater utilisation of the public infrastructure (which has been greatly enhanced by the action of the Funds) by the enterprise sector. Effective absorption depends on finding solutions to this problem.

Particular attention is needed to ways of mobilising and increasing the demand for RTDI from industry in the lagging regions. In the majority of cases this will involve greater attention to innovation, to networking and linkages, to co-operative structures and clusters, to technology transfer, to diffusion of information, technology auditing, the mobility and placement of human resources and less to research and research infrastructures.

It is essential to work to improve the absorption capacity of regions, performers and participants, and to overcome the absorption versus quality question. Improving absorption capacity, as well as quality and performance must be key objectives for the future. This issue ought to be addressed in the submissions from Member States and they ought to indicate whatever plans they have to tackle the absorption problem.

Some improvements in absorption can be achieved by focusing on the high performing firms in LFRs, large and small. There are two reasons for this suggestion. Firstly, spreading R&D support around among many firms is not a formula for raising all boats. Secondly, firms learn best from each other. Creating and fostering exemplars may be the best way to induce others to follow suit. More support directed towards the 'performing companies', implies a more selective approach in the allocation of funds to those companies with a demonstrated capacity to use the funds well. The same rules might also apply to regions and to institutions. Performance ought to become a more explicit criterion for the 2000/06 round of funding. This is not to suggest excluding new entrants to the system. Both populations need to be addressed, each with different means and intensity.

Absorption may also be improved by focusing more support on the development of industrial clusters and networks. The success of efforts in Saxony to establish microsystems clusters, in North region of Portugal with the footwear industry, in the Central region of Portugal with moulds, the networking initiatives in Finland and in Sweden with the timber processing firms participating in the small Trainnova cluster, are examples which suggest that progress could be made with industry on this basis. Appropriate indicators are needed to make sure that this clustering approach creates effective externalities.

More attention is also needed to the quality of innovation which the Funds are used to support. In some instances, Portugal, for example, considerable funding has been provided for industrial modernisation and re-equipping, where the real innovation content may be rather limited. A strong orientation supporting product innovation should be a key theme for the next round of funding. This may require more innovative policies, but it is the only way to contribute to restructuring and new employment.

Transfer processes in lagging regions depend on skilled and committed mediation and bridging, a business which is rapidly becoming more professional. In this context, the performance of the bridging institutions in these regions and the composition of the bridging capabilities, need to be addressed. It is important to examine the question of whether the Funds should attempt to influence the composition of technology brokerage, bridging and technology transfer systems in beneficiary regions, in favour of a stronger private sector element, especially where these systems are currently dominated by government, university and para-university organisations. Notwithstanding some mixed experiences with private sector intermediaries, Greece for example, it is important to bring a more commercial approach to technology brokerage and bridging in all regions. This will be appreciated by companies and will sharpen the response of the bridging agents to commercial requirements, especially to industrial needs and deadlines. The operation of ISQ (Welding Institute) in Portugal for example, would be a useful model for consideration.

Programmes which may be characterised as 'demand driven' and focused on business and industry are proving more effective, for example in the new German Laender, in Ireland and Northern Ireland and in the North region of Portugal, and in Finland, to cite a few examples. Grant support for RTDI in Northern Ireland favours industry over universities by 3:1. In Finland, more than 650 out of a total of 750 initiatives supported, are targeted at business development. The business and industrial orientation of the Funds in these regions is noticeably stronger than in Greece, Spain or Italy, for example.

Systematic and continuous analyses of firms' needs are required, in which firms themselves and their industry associations should be deeply involved.

Conclusion (i):
The absorption capability of the enterprise sector for RTDI support needs to be significantly improved.

Conclusion (ii):
The structural composition of the overall RTDI package of incentives in most Member States/regions needs to be changed to achieve (i) above.

Recommendations:
Required structural improvements in the composition of RTDI and changes in the range of instruments used for technology transfer and innovation in LFRs, include the following:

- The resources available for the support of <u>innovation</u> need to be increased, relative to the levels of support for research and technology, more especially for product innovation. Process and organisational innovations can also be encouraged, but mainly when elements of risk and novelty are included. Otherwise, they are likely to be financed by companies themselves in their efforts to cut costs.
- The proportion of BERD in total GERD needs to be increased. This is a key indicator. Increasing BERD/GERD in regions where BERD is low is very important. In regions like Sterea Ellas, where the ratio is high due to the absence of GOVERD, an overall change of regional strategy is necessary.
- Programmes which promote co-operative projects with firms, better participation of industry and industry associations, should be favoured.
- The population of SMEs participating in RTDI needs to be increased. Targets for first timers need to be set in agreement with the targets for increased emphasis on performers.

- More utilisation of transregional/transnational co-operation and interfirm networking and for ITT is necessary. Yet this has to be carefully selected and designed, taking geographical and proximity arguments into account.
- More multiannual and integrated support programmes for the development of industrial clusters and networks, such as in Portugal (moulds, footwear) Sweden (timber processing) and Saxony (microsystems) should be encouraged.

Conclusion (iii):
There has not been enough attention to building the capabilities of the productive and business sectors for RTD performance and utilisation.

Recommendations:
Initiatives to improve absorption capacity, which should be sought in proposals from Member States for the next round, ought to include some of the following:

- Human resources
  Programmes to improve the human resource capabilities and skill profiles of firms, especially training programmes.[1] Training needs, including technicians need to be assessed. The emphasis should be on the needs of firms, not the needs of trainers. It is important to address communication tools to improve awareness of needs. These may include 'open-house' arrangements, training audits, establishment of expert groups etc. Delivery mechanisms also need to be addressed - new technology for improving access to and delivery of training for SMEs, mobility schemes, private sector participation in training provision etc.

- Skills Placement in SMEs
  Programmes to support the 'placement' of new graduates in SMEs. These should focus on graduates, not PhDs, and especially on engineers. The Techstart initiative in Ireland is a good model to follow. The key idea behind these placements is the benefit for the productive sector and for the improvement of human capital, not the formal degree. This is not to say that formal PhD placements should be eliminated, rather that one should design the programmes in a way to ensure that both the student and the company benefit from a broadly based supply of skills.

- 'New Blood' for RTDI
  Initiatives to increase the population of RTDI-performing SMEs. Special attention and preferential funding should be provided for 'first time' RTDI performers. Get them to appreciate the value of in-company RTDI.

- Industrial Associations and Networking
  Assist industrial associations in their role as a nucleus for small firm networking/clustering. Help the industrial associations to identify firms' needs, establish linkages with centres of research and technology and to promote technology transfer to firms. These associations can be valuable intermediaries and help to strengthen networking between firms themselves and between firms and the main sources of technology in the region, and outside it. German, Portuguese and Greek experience supports this concept. Identifying and transferring best practices on intermediaries is important as is the early intervention of policy makers to keep them on the right track.

[1] ESF is supporting continuous training with RTD implications (training of managers, IT training,...). These ESF initiatives, which are substantial, have not been covered by this evaluation.

- Co-operative RTDI Initiatives
  Encourage RTDI co-operation between regional centres of research, universities etc and regional SMEs. Provide strong financial incentives to induce SMEs to seek out assistance from regional centres of research and technical services.
- Technology Auditing
  Establish programmes of technology auditing for small firms. Based on the results of such audits, SMEs would be offered assistance for technology enhancement and for the integration of technology with production and business planning in the company.

- Internationalisation
  Assist internationalisation among regional SMEs, especially export marketing, access to information, assistance with quality and design standards, finding partners for joint ventures and technology licensing. Select the fast moving, technologically aware and dynamic SMEs, as the initial target for these initiatives. Co-operation between Ministries of Industry and Ministries of Research and Technology is an important prerequisite for success in this area. Like the case of co-operation with Ministries of Education, these links need to be formalised and monitored based on a set of targets and indicators.

- Funding for innovation
  The local availability of some relatively modest financial support for a variety of initiatives would enable local government/agencies to provide a flexible response to the needs of individual small firms for innovation support. Funds would be managed within the region by the appropriate Regional Government office and would be capable of providing a <u>flexible</u> response to different local requirements for innovation support services and technology transfer initiatives, especially to small firms. Designing such funds is not an easy task and they should be introduced gradually in the more mature regions. The key point is that innovators must have access to enabling mechanisms.

Management and implementation processes

Management inefficiencies and discontinuities are reducing the effectiveness and impacts of the Funds. Interviews with small firms show that the most important obstacles for companies to participate in RTDI schemes are the long response times of the agencies and bureaucracy – except in Northern Ireland and the Republic of Ireland. Dissatisfaction is very high in Italy, Austria, Germany and Portugal. New and less complex management systems are needed.

It is evident that Member States are making serious efforts to reduce bureaucracy, Italy, for example, and there have been general management improvements since the last round. It is also evident that some agencies manage most effectively, though these tend to be exceptions. Management problems, slow moving administrative systems, complex legal procedures and requirements continue to slow things down and to reduce the efficiency and impact of the Funds. Private company participation is influenced by this situation, and the likelihood of supporting projects with substantial commercial benefits is reduced, as such projects need basically rapidity and flexibility. In terms of mobilisation of demand, the improvement of management systems, faster decision making etc., could be an important step. At present, administrative systems are so slow that they are affecting participation by firms, especially the more dynamic ones who appear to prefer not to get involved. It is characteristic that even in the survey of firms benefiting from the Funds, this criticism was severe and scored extremely high in countries like Italy and Greece.

Performance monitoring needs to be strengthened - <u>everywhere</u>. Performance monitoring at both project and programme levels is universally weak, and arguably one of the easiest things to remedy. The lack of relevant indicators is not an excuse here. There are many ways to monitor progress and performance which do not require indicators. Of course, wherever performance indicators can be improved, this should be done.

While financial auditing is frequent, there is too little attention to regular performance appraisal with contractors, especially as regards the technology achievements and problems associated with projects, milestones and technical targets. Across all participants, this aspect is in need of improvement - a matter for Commission attention as much as regional and national administrations.

On the positive side there are some examples of management systems and procedures which can act as exemplars or models. Our suggestions on these are presented in the section on Good Practice and the Policy Lessons Drawn - Section 4.3, Chapter 4.

The problem of absorption versus quality is always an issue. It is essential that there should not be a trade-off with quality, in order to speed up absorption. Absorption continues to be an important issue therefore, as it was in the previous period.

The Ministerial division of responsibilities for RTDI at the national level in Member States is a sensitive issue. But it is necessary to say that some of the existing arrangements suffer from fragmentation and lack of co-ordination. Specifically, it seems inappropriate that education and university Ministries should be responsible for industrial innovation, technology transfer and SME support schemes, as is the case in Italy, Portugal and Spain, for example. Such arrangements give rise to questions about the separation of policy from implementation, as well as about the effectiveness of the interface between these Ministries and the Ministries with responsibility for industry. It is arguable that innovation schemes and structures are more appropriate (and likely to be more relevant) under an industry Ministry, rather than a science Ministry. If the industrial orientation of the Funds is to be increased in the future, then this is an issue which will have to be addressed.

There are discontinuities between some agencies responsible for management of the Funds at national level which need also to be addressed, there are some overlaps between programmes, while others which should be mutually supportive, appear to have little co-ordination. SMEs in Italy can apply to either the national or regional parts of the Funds, or to PEDIP or PRAXIS in Portugal, and there is need for improvement in the communications between CICYT and CDTI in Spain, to give just a few examples. SMEs in Sweden feel that the missions of the regional authorities managing the programme (the municipalities and Lansstyrelsen) overlap with the missions of national agencies (NUTEK and the Ministries). There are examples of weak regional level management also, Sicily for example. (See Italian case studies in Volume 2) Here the problems are weak programme design, fragmented and uncoordinated management responsibilities and poor project selection procedures. Some projects are selected politically, without any tender procedures e.g. Measure 10.4 of the POP. Communications between national and regional levels also need to be improved, in Italy, for example.

The Commission, of course, is not responsible for how Member States choose to arrange these functions, but nonetheless, the situation is fragmented and sometimes rather rigid as between Ministries, and all of which leads to unsatisfactory results. In this context, some of the explanations are political more than institutional. Nonetheless, if the notion of complementary actions has any meaning, Member States should ensure that the institutional arrangements in place for the management and distribution of the Funds are appropriate, efficient and well co-ordinated. This would be a valuble complementary action for Member States. It is important for Member States to be in a position to present their own governance structures based on principles of efficiency and accountability, rather than on historical or political perspectives.

Conclusion:
Management and co-ordination problems at both national and regional levels, are reducing the overall effectiveness of the Funds.

Recommendations:

- The separation of policy from implementation (Government Ministries for the former and executive agencies for the latter) appears to be an effective model in the countries where it has been adopted. The 'Executive Agency' model (an autonomous government agency with responsibility for the management and implementation of the programmes/measures, but not for policy) has been successful in Spain (CDTI) and in Ireland (Enterprise Ireland/Forbairt). This concept might be appropriate for Italy and others.
- Co-ordination of the RTDI Funds at Ministerial levels needs to be strengthened. There are examples of rigidities and unsatisfactory co-ordination between some of the main players at national level in a few countries.
- Monitoring is weak, almost non-existent in many instances. Independent and impartial technical assistance, providing guidance and assistance and ensuring that plans are kept on target needs to be provided. New systems of real time monitoring (as distinct from financial auditing) need to be put in place. An Observatoire or technical assistance unit should be considered by the Commission.
- Evaluation culture needs to be strengthened. The mid-term reviews alone are insufficient. It is the continuity of the evaluation process, its regularity, and the assurance of feed back mechanisms that make evaluations on an effective tool, as demonstrated from the case of the Nordic countries.

Learning and interaction

Learning and interaction processes are mutually dependent and fundamental for continuous change and innovation. Theory on systems of innovation has demonstrated that these are prerequisites for transition from low wage competition to a learning economy. Inter and intra-organisational learning are the foundations of innovation. Routinising interaction is a key feature distinguishing more developed economies.

Indications that the Funds have really contributed to learning and interaction are limited. The key components are human capital, interaction between actors in the system and institutional learning. Human capital interaction has been promoted through the placement schemes, but remains limited. Inter-organisational interaction is most successful in the cases of effective cluster building, but this has been limited. Finally, regions do not appear to learn from each other. All seem to have to find out for themselves. Learning is replicated. There is no evidence that a co-operation culture is emerging independently of support schemes. Admittedly, this theme is the most difficult to implement, because it constitutes the introduction of new behavioural rules.

There are some good examples of explicit policies to encourage interaction between universities, research centres and business. The industrial clustering in Saxony region and the PATs of the Irish programme have been described in the profiles and in the case study section of the Irish report. (Vol. 2). There are others, for example, support for networking and interaction is a feature of the Finnish programme supported by the Funds. Networking is stimulated between educational institutes and SME's. The Design Park Project, in which the University of Lapland is a lead player, supports interaction through the provision of professional services to industry, particularly in the field of prototyping. The intensive interaction between industry and university and the type of services provided by the university can serve as a good example to other universities. he proximity of the Oulu Technopolis and Oulu university are important for the region and there are linkages between these and small high technology firms in biomedical and microelectronics fields, inside the region. Six new polytechnics established recently in the region, with Funds assistance, also support interaction between business, education and research. More than 18MECU is specifically targeted at stimulation of networking between educational institutions and small business in this Objective 6 region.

At the firm level, overall the Funds do not appear to have greatly stimulated the level of interaction of firms themselves with each other. See the results of the SME survey in Section 4.4, Chapter 4, for example. There are a few exceptions, as in the Trainnova project in Sweden, where a number of small firms in the wood processing sector are working jointly on a funded project and learning the benefits of RTDI co-operation.

Policy makers need to consider learning and interaction as a culture rather than as individual actions. It includes the adaptation of institutions i.e. formal and informal rues. For the formal rules the transfer of good practice is highly relevant.

Conclusion:
Opportunities for learning and interaction have not been exploited sufficiently.

Recommendations:

- Co-operation, co-ordination and interaction between the central Ministries involved in RTDI need to be improved.
- Interaction and transfer of knowledge depends on the quantity, quality and relevance of human resources. Despite difficulties, more attention is needed to the relevance of graduate output to industrial needs and to the relevance of training programmes.
- PhD programmes need to be reviewed to improve the relevance of PhD training for work in industry.
- Effective clustering and networking needs to be promoted around a central framework of learning, exchange of information and user-producer interaction.

Policy development and delivery

In this area, it is important to distinguish policy development from policy delivery. The problems exist in the policy delivery phase, especially. Good schemes and programmes are failing because of weaknesses in management. Part of the problem appears to be that there is limited experience of designing or managing industry oriented programmes. Most regions do not yet have this type of experience

There are some problems with policy formulation too. The strategic vision is not always apparent at national level. Priorities are not always clear and funding is being dispersed over too many areas. Building critical mass on the basis of established strengths requires a clear focus on priorities. Concentration and specialisation will now be more important concepts for the Funds and for the participating regions. Clearly, the next stage needs to pay more attention to fewer and stronger projects, to clearer definition of priorities and to assisting the establishment of critical mass in well selected areas and technologies. This will place a major emphasis on planning and policy formulation and on monitoring to ensure that these are not just aspirations and empty promises. Performance based systems would help to introduce greater selectivity and focus.

Greater selectivity will also be necessary for the future viability and sustainability of funded programmes.

At the regional level, technology and innovation now occupy a prominent position on the policy agendas of a growing number of regions. The approach at regional level is becoming more structured and more systematic, as regions establish new institutional arrangements to assist innovation, new startups and technology transfer. A growing number of regions are now developing regional innovation strategies, as a result of the Funds, and the stimulus to regional development policy is growing.

The appropriate division of responsibilities between national and regional authorities is an issue. The relevance of proximity in the innovation process has been demonstrated, especially for traditional sectors. But, on the other hand, policy design and implementation skills at the local level are often insufficient, and in LFRs more than in core regions. Therefore, a strategy is needed to define long term targets and their feasibility as to the most appropriate level of management. It is difficult to avoid the issue of power play in any assessment of the merits of national as against regional/local action, but the ultimate aim ought to be to empower the regions to the extent that they can accommodate this. This said, it is also important that regional programmes are not just mimics of those available nationally. For example, the IGAPE (Galician Institute for Economic Promotion) in Galicia in Spain has copied the Global Grant approach of CDTI (Centre for Technological Industrial Development) at national level (it is apparent that the IGAPE scheme tends to support SMEs more than CDTI does).

The problem is that the regional actors are not ready. Nonetheless the strategic planning process at regional level is to be strongly recommended. Existing initiatives (the RTPs, for example) to stimulate this should become more closely linked to, and more persuasive (though not necessarily mandatory) in decisions on Structural Funds support for RTDI in future.

Subregional considerations also arise here. It is clear that, in large regions, (some regions in Europe are bigger than Belgium), the subregional location offers better and closer proximity and shared backgrounds, which encourage clustering and networking between firms. The Italian experience shows that the local level may be the most appropriate for synergy.

An issue for the Commission is the extent to which some Member States now depend on Structural Funds to meet their obligations towards national research support. Government funding of R&D in Portugal was described as 'symbolic'. The PRAXIS programme is now the mainstream support for public sector research in Portugal, while in Ireland the government share of GERD has now fallen to its lowest level ever, at 23%. It would be paradoxical if further increases in the Funds in favour of RTDI were to be met with reductions in the contributions of the Member States own governments.

There is evidence that some regions, and possibly quite a few, may be ready to consider ways of obtaining greater financial leverage for the monies made available from the Funds, either through repayable grants, loans, loan guarantees or similar forms of research and innovation financing. The Spanish repayability arrangement, which is managed by CDTI, is an exemplar. (See the Spanish report and case study on CDTI in Volume 2) Care is needed, however, not to introduce a disincentive to innovate (to penalise success) or to undertake technical development, especially for the smaller firms and those in difficult economic environments.

It is felt however, that some changes in the conditions for financing industrial innovation and research would be feasible now in many regions, especially with the larger firms, whom, many admit, would have done the research, or undertaken the development, even without the grants, although the scale of development or the timing of its launch may have been accelerated. There seems to be an emerging consensus on this latter point and many of those interviewed will admit that it is likely that (large) firms would have undertaken the project without the funding. Additionality and deadweight, especially in large, near to market, industry support schemes continue to be a concern. The issues are complex and difficult to address. The evidence of our investigations would confirm the view that additionality is being achieved through bigger, faster and more timely initiatives with the assistance of the Funds, than would otherwise be the case.

Conclusion:
Policy design needs to become more ambitious and follow some universal rules, despite the diversity of the regions.

Recommendations:

- Strengthen the link between the outcomes of the DGXVI/DGXIII regional planning initiatives (RTP/RIS/RITTS) and the design of the Funds for RTDI. The lessons of the RTPs have been useful, though it is important to stress that the fact that regional actors all agree on investment programmes for a region is not enough. While a local consensus may be necessary, it is not sufficient, without some independent validation.

- Involve the private sector more in RTDI policy design. In some cases the involvement of industry is a matter of policy, while in others it may need legislative amendments, but good practice examples show that the public-private co-operation is ultimately the most effective way that policies can be designed. The case of Central Macedonia (outlined in Section 4.3 Chapter 4) presents an interesting and ambitious model.
- 'Performers' (regions. firms and regional administrations) should be given more opportunities, while at the same time increasing the competition between them.
- Non-performers should be given smaller amounts, but more chances to adopt self-motivated bottom up strategies and initiatives.
- There are key issues of institutional design to be addressed, especially the most appropriate ‘division of labour’ between the centre and the regions. It would be appropriate to provide greater discretion to the regions themselves in the management of schemes for SMEs, provided they can demonstrate their skills and interest in training.
- There is too much dispersion of the Funds on a myriad of small projects and programmes. Some rationalisation is needed.
- There are arguments for the introduction of repayability into industrial grant schemes, along the lines pioneered by CDTI in Spain, especially for the larger companies and near to market projects. Care is needed however, not to make innovation more difficult for SMEs.

Economic impacts and Community added value

The available evidence indicates that the direct economic impacts of the Funds for RTDI in the beneficiary regions, are so far fairly modest. However, a much needed strengthening of the long term capacity of regions for economic development is occurring, with the assistance of the Funds. The additionality of the Funds is also evident, as it apparent that many, if not most, of the investments supported could not have been undertaken by the region or Member State, without the assistance of the Funds. The availability of the Funds is speeding up the enhancement of RTDI capabilities, and improving both the pace and the scale of development.

A wide range of new and improved RTDI facilities has been supported, mainly in universities and in government laboratories. (See Chapter 4.1 for empirical evidence). Therefore, the Funds are significantly improving the capacity of Objective 1 and 6 regions of the Union to undertake research and technological development.

Research in industry is also benefiting, but to a lesser extent. Examples include, the new Laender, Castilla la Mancha, Central Macedonia, Ireland and in Northern Ireland. In Northern Ireland, the funds available to SMEs are helping to change the approach of SMEs to research. A more organised and strategic approach is taking root in many of the beneficiary firms. It is apparent also that demand driven/industry oriented programmes in Germany, Ireland, Austria, the North region of Portugal for example, are effective and are having an impact on the enterprise sector. The Finnish programme (Objective 6 region) is especially strong on support for business development. Out of 750 projects supported by the Funds for RTDI, 650 of these are targeted at the establishment of new and support of existing businesses and the improvement of the business environment in the region. These three programmes have been responsible for creating more than 700 new jobs.

The importance of Public Support for RTD in small firms is rated very highly by firms in all countries. More than 70% of those interviewed said it was ‘very important’, and especially for assisting Product Innovation. (See Section 4.4 Chapter 4 for details of the SME response to the Funds).

Traditional industrial sectors (footwear and ceramics in Portugal, timber processing in Sweden, food processing in Ireland and in Northern Ireland, the wood sector, clay processing industry, natural stone and agri-food sectors in Spain, agri-food also in Ireland, ceramics in Nord Pas De Calais) have all benefited from the Funds. At the high tech end, information and communications capabilities and data communications networks, have been strengthened in Flavoland (The Netherlands), in Greece and Burgenland (Austria), in Corse and in Hainaut. (Belgium) Programmes in Advanced Technology in Ireland, Advanced Technology Centres in Northern Ireland and high technology clusters in Saxony, Germany have also been beneficiaries of the Funds.

But these are some of the best examples. Despite positive experiences and improvements, concentration on capacity enhancement and less attention to the more challenging problem of commercial exploitation of research, remain in many cases the key problems in LFRs and among the most important to be addressed in the next round. Research in the service of competitiveness and improvement in living conditions are key considerations for the future.

Public sector capacity enhancement of RTD has been the main benefit of the 1994/99 period. At the Community of RTD level, this improved capacity is helping the regions to participate in international research, for example in the Framework Programme, and to this extent the effects of these two policies (Framework Programme and Structural Funds) are complementary. All the less favoured regions have used the Funds to improve their RTD infrastructures and facilities for research, and to thus enhance their research performance, as the evidence from the fieldwork demonstrates. In addition, regions with an internationally recognised R&D capability, Kriti, Dytiki Ellada, Attica in Greece, Ireland, and Lisbon Tagus Valley in Portugal, for example, have been able to participate intensively in <u>both</u> the CSFs and the Framework Programmes. RTD absorption capacity is strong in these regions and the beneficiary organisations in these regions consider both instruments to be complementary.

It is also evident that quality centres of excellence in areas of strategic importance to a region, can help to stimulate inward investment to the region, will influence the quality of this investment and will have beneficial impacts on the quality of human resources and on education and training. The Funds and the Framework Programme are both important in helping less developed regions to establish such capabilities.

We are not therefore, in favour of 'dumbing down' the research actions of the Funds in the less favoured regions, as implied in the Second Indicators Report, when it suggests that the Funds support projects "-- even if these R&D projects do not match the high scientific standards imposed by the current Framework Programme...". We would however favour more competition for research funding from the Funds, as this is the only way to ensure that quality is maintained.

There is some danger of overlap and competition between these two funding sources in the LFRs, <u>especially regarding the funding of high quality research.</u> Even in the regions mentioned above the supply of high quality research personnel will be limited and there may be some 'crowding out' by the Structural Funds of the Framework Programme. The latter is considered more difficult to access, because of the level of international competition involved. However, we have not found many cases of this in the fieldwork. In fact, some agencies actually prefer the Framework Programme, because it allows direct access to Brussels, thus bypassing local patronage and bureaucracy. Also, access to the Framework Programme is important for regions trying to retain high quality research personnel in the region and to improve the international connections and reputations of the region.

From a regional development perspective, it is clear that RTD projects, which must be funded if local industry is to benefit, will generally not satisfy the very high scientific excellence requirements of the Framework Programme. SMEs in less favoured regions do not need leading edge technology. Furthermore, they will not have the complementary assets to exploit it, even if exposed to it, and the spillovers will be minimal. Supporting R&D in firms is unlikely to lead to innovation, unless there is access to risk and venture capital for example, or where the regulatory environment discourages innovation. Supporting centres of excellence in backward regions will add very little to the local economy, if linkages to the local economy and production are not well established.

It is important therefore, that the action of the Funds does not simply mimic the Framework Programme, nor that the Funds become a second chance for failed Framework Programme applications.

The Funds should focus more on integrating RTD into regional economies. They should aim at embedding the existing regional RTD capabilities into the productive fabric of the region. This will need strategic planning and priority to innovation, networking, co-operation and communications actions, mobility of human resources and skills. New guidelines are needed for this.

In focussing more on innovation, the Funds should address dynamic elements such as networking, communications, interaction and learning, areas which the study has shown to be weak. The Funds should encourage more innovation and focus more on support for complementary assets. The development of well-elaborated regional innovation systems is seen now to be very important. Regions which are converging seem to be embedded in countries with well elaborated innovation systems. More support for innovation, entrepreneurship and for complementary assets is required.

Where the Funds provide support for high quality research, the key issue is selectivity and prioritisation. Less favoured regions cannot become international centres of research excellence in all areas. But they will have to do so in some, if they are to function in a globalising economy. Prioritisation is therefore crucial for the less favoured regions and this requires stronger strategic planning by the regions in order to fix priorities. There is evidence that this is occurring at regional level. It is clear that stronger strategic planning, as the basis for regional support for RTD, is more crucial for the future. Technology gap indicators are simplistic and dangerous and lead to concepts of equalisation of RTD capabilities, which is not a plausible policy goal.

The reasons why the Funds should continue to support high quality research in regions that already have an established RTD capacity and which are capable of competing at the international level, as in the Framework Programme, would need to be clearly elaborated.

Where the Funds are used to strengthen high quality research performance, the competition for these funds needs to be strengthened, if quality is to be ensured.

And the inter Directorate co-ordination of both instruments needs to be strengthened.

The principle of partnership, which is central to the operation of the funds, ought to include stronger contributions from national and regional authorities, from the social partners and from other non-governmental organisations which benefit directly or indirectly from the Funds. Apart from the matching funds provided by Member States, complementary actions by Member States are needed to address ‘process inefficiencies’ (management, monitoring, evaluation, etc.) and in order to optimise the impacts of the Funds, at both national and regional levels.

In more general terms, Community added value ought to be a more explicit element of the partnership concepts underlying the relationships between the Commission and the beneficiary. It seems logical that unless this occurs, Community consensus on support for structural assistance to LFRs is unlikely to continue. See Table 6.1 for summary of community added value impact of the Funds and Section 4.2, Chapter 4, for the analysis.

We have not been able to assemble a consistent set of economic or financial indicators for all regions. This is a major challenge for the next period. Because of the limitations of data availability, we are forced to depend on proxies, estimates and exemplars, for evaluation. Core indicators are required which can provide a basis for ongoing monitoring and final evaluation. Care is needed to avoid undue dependence on linear input indicators, (technology gap indicators measured as inputs of RTD) which are driving the Funds towards further capacity enhancement, without proper consideration of utilisation issues. DG XVI seems the most appropriate actor to initiate discussions with Eurostat, the Member States and possibly other interested international organisations like the OECD.

Conclusion:
There is evidence to indicate that the future growth capacity of Objective 1 and 6 regions is being strengthened by the support from the Funds for RTDI. However, complementary actions taken by Member States have not been adequate to maximise Community added value.

Recommendation:
Relevant complementary actions by Member States could include:

- Improving the strategic underpinning of regional programmes. More explicit and customised regional strategies are required which will reflect regional path dependencies and identities.
- Internal processes which need the attention of Member States include having in place an effective policy delivery system, having an effective evaluation and monitoring systems and improving the co-ordination between the main Ministries involved at the national level. Some examples of good practices are outlined in Section 4.3.
- Better integration of RTDI policies with other non-RTDI policies so as to enhance the complementary assets needed for full exploitation of RTD potentials.
- Improved real time monitoring arrangements, which are not driven solely by accounting requirements and obligations.
- Increased efforts by national governments to improve the regional distribution of RTD capabilities.

2.3 Targets and instruments for capacity-building in the accession countries

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It is a feature of the transition economies that all, from the technological point of view, are located in what we might term the “modest-to-medium” bracket on the world scale and also that their combined S&T capabilities and skills are quite remarkable.

The Central and Eastern European Countries (CEECs) have undergone a crucial transformation in their economic and political systems since the Berlin Wall collapsed. To take advantage of this transition for the improvement of living conditions and progress, individuals, enterprises and countries must show themselves capable of rapid adjustment and continuous innovation. This is the challenge for all of the transition economies. In order to meet this challenge, however, the countries have to reformulate their policy-making process and also their way of thinking on economic, innovation and science policy matters.

The advanced economies are more than ever dependent on the production, distribution and use of knowledge. This new trend is leading to the revision of economic theories and models and of the basic systems of innovation and of science models – all on a world-wide basis. In consequence, the CEECs must react to the new, emerging pattern of the knowledge economy which renders a change in attitude to S&T and to innovation policy-making most urgent.

The countries in transition have to increase their capacity in the area of modern science and technology and in innovation policy-making. There are many layers of such capacities which have to be reformulated in order to achieve the overall targets: the modernisation and internationalisation of these economies as a pre-requisite for improvement. This paper focuses on two issues of such capacity-building in policy-making: (1) the penetration of modern policy-making instruments into Hungary and (2) the presentation of initiatives to upgrade the intellectual capabilities for S&T and innovation policy-making in CEECs. (CIPRE)

A. The employment of modern policy-making instruments

The main instruments of modern S&T and innovation policy-making may be classified into four basic groups:

1. Evaluation
2. Foresight
3. Technological assessment
4. Indicators

A.1. Evaluation

Evaluation provides indications relating to the achieving of objectives for S&T policy-makers. Policy-makers need from such evaluation their own legitimisation or justification, the targeting, controlling and fine-tuning of policy and an analysis of policy rationale. (Kuhlmann) Funding decisions and other science policy issues must be based on the evaluation of performance.

In terms of timing, evaluation may be ex-ante, interim, retrospective and also follow-up. (Pre, interim or post-evaluation have different functions in the decision-making process.) Ex-ante evaluation may prevent weak proposals being advanced, unsuitable programmes being run and teams which are well below their critical mass being allocated less knowledgeable researchers. Interim evaluation supports decisions to continue, modify or interrupt projects and also allocates personnel. Follow-up evaluation helps decisions on further support for the organisation in question, for its reorganisation – or, indeed, for its closure. The follow-up programme evaluation produces recommendations for further programmes, projects and grants. It results in the emergence of a longer-term strategic planning outlook, of an agenda for methodological research into the dynamics of the research system and affects future funding, if any.

Table 1: The scope of evaluation by domain and its presence in Hungary

Domain	Focus	In Hungary
S&T Policy Innovation policy	Aim, scope, relevance of policy. R&D initiatives. Continuity-discontinuity. Goals and national strengths.	Not yet
S&T System	Scientific infrastructure. Range and type of institutions (including funding agencies and performing organisations). Degree of centralisation (central vs. regional). Extent to which industry performs R&D. Practices of governance.	Evaluator: OECD 1993, 1995 (published). US Expert group (HAS) EU expert groups. Bidding system. Qualification of scientists (KMÜFA, OTKA).
Programmes	The sponsors of a research programme wish to know how successful it has been in achieving its aims. Evaluation programmes examine the economic and social impact of programmes and projects.	EUREKA participation. Balaton programme – OMFB MEC. (From travel grant, member fee system to success rate of supported projects). National participation in EU programmes.
Projects	Appraisal, competitive selection of projects, merit, peer review. Ex-post checking that they delivered as promised.	By Foundations' (KMÜFA, OTKA) expert groups.
Research Organisations/Teams	Performance. Disciplines.	Universities (accreditation), core funding, research institutes.
Research Players	Each output of individual researchers. Referring publications.	Career evaluation.

For credible evaluation need independent experts. The evaluators may be:

- Ad hoc expert evaluation group
- Panel experts
- Institutionalised evaluation: organisations responsible for systematic, periodic evaluations (Kuhlmann, Laredo and Mustar, Georghiu)
- "The ways in which evaluation is approached in [the Member] countries reflects the political and administrative culture of those concerned" (Gibbons and Georghiou 1987)

A.2. Technology Foresight

Technology Foresight is a systematic attempt to look into the long-term future of science, technology, economy and society. Its aim is to identify the areas of strategic research and the emergence of generic technologies likely to yield the greatest economic and social benefits (Martin 1995).

The first Hungarian Technology Foresight Programme (TEP) was launched in 1997, and its results were published electronically in 2000. The Steering Group and the 7 thematic panels assessed the current situation, outlined different visions (scenarios) for the future and formulated policy proposals. Statements for a two-round Delphi-survey were formulated by some 200 panel members. (Havas, 2000).

The 7 thematic panels analysed the key aspects of the following areas:

- Human resources (education and employment);
- Health and life sciences;
- Information technology, telecommunications and the media;
- Natural and built environment;
- Manufacturing and business processes;
- Agribusiness and the food industry;
- Transport.

The main concern of TEP participants was to identify major tools to improve the quality of life and to enhance international competitiveness. They emphasised the crucial importance of knowledge creation, exploitation and diffusion in all thematic areas.

From the point of new capacity-building for policy-making, not only are the findings of the TEP process crucial; so also is the exercise itself. Before this exercise very many participants had never been involved in policy debates. The (carefully selected) panel members had very different scientific and professional backgrounds and different generations participated. Not only were these 200 panel members involved in policy debates but also many other experts who were selected by the “snowball” method, in responding to the Delphi- style questionnaire. They thought about such policy questions as the scientific environment, the importance of human resources, of regulation and institutions in co-operation and networking.

Technology Foresight has become a promising policy tool for strengthening relations and interactions within the innovation system so that knowledge can flow more freely among the constituent actors and the system as a whole can become more effective in learning and innovating.

A.3. Technology Assessment

Until now the Hungarian performance in this field has been limited and the most important activity was the dissemination of Western knowledge. Selected literature was published in Hungarian; study-tours and short courses were organised for technical university professors and for state administrators and various new classes were introduced into university courses.

A government decree was issued in 1994 to set up a Technology Assessment Bureau, but this decree has not yet been activated and there is no agency responsible for these matters; nor has any Parliamentary Committee member been involved in TA debates. However the environmental protection issues are relatively well represented in the government sphere, although few ex-post TA studies were born after various catastrophes such as the poisoning of the River Tisza.

A.4. S&T and Innovation Indicators

Indicators are both traditional and modern policy-making tools, and they are also important nuclei for all of the other modern tools discussed above.

The main cause of the lack of an adequate information system in the transition economies is well known: the legacy of socialism, where measurements were developed for arriving only at macro-economic decisions for the directly (or indirectly) planned economy. Information for business and for general public consumption was also neglected. Measurements which could demonstrate the prestige of scientific-technological progress were very important, and it was much less important to prevent society from investing in projects with a negative return. These interests had a strong influence on the collection, production and use of statistical data, indicators, evaluation and so on.

Adequate, internationally comparable statistical indicators are needed to support policy formulation - including the related financial decisions.

Such indicators have a very important role to play in allowing policy-makers to establish priorities and to make their decisions on the basis of a better knowledge of the situation and of the ways in which scientific and technological policy can impact on the socio-economic objectives which they wish to reach.

The role and importance of S&T indicators as modern S&T policy-making tools are unquestionable. The indicators may not be the ultimate solution for policy-makers, but without them it is almost impossible to make good decisions in this field. The various types of S&T indicators may reflect on past trends and circumstances, contribute to understanding the current environment and guide the development of future policies. Indicators also function in different policy-making areas, such as evaluation, stocktaking, discovery, framing and benchmarking - and they underline the most important perspectives, although no single data set is able to show the complete picture.

In stocktaking, the most important questions relate to finance. Stocktaking provides a policy monitor indicating whether or not the desired “portfolio” has been created, and major national debates have been generated around questions of expenditure on basic research, health and the role of the state, as well as on business expenditure. Further end-products can include the best ways to communicate with policy-makers, the impact of indicators, objective financial criteria and the problem of a minimum set of indicators and their time sensitivity.

The discovery of potential policy relates to issues which need to be explored such as brain drain and circulation and the need for frame indicators, which provide an objective, common basis for policy discussions and analysis, the search for data about human resources and higher education to explain how the numbers and distribution (by field) of graduates is determined for decades to come. In Hungary the German “green-card system for IT experts has encouraged a policy response: in increasing state-supported enrolment in IT degree courses. Hungary has no wish to lose her ability to be competitive in the IT intellectual field; nor does the state wish to hinder mobility.

Benchmarking is of growing importance in that it provides comparisons with other countries who can, at the same time, be both similar and competitors, and who are perceived “best /good-practice” performers.

The functions of indicators in policymaking include informing policymakers in the course of their deliberations, supporting priority-setting and providing knowledge through which S&T policymakers can have an impact on the socio-economic objectives which they wish to reach.

There is a need for the CEECs themselves – and for a wider audience within them - to understand better the relationship of input/output indicators and the need to promote the better use (in context) of indicators by their policy-makers. The same ‘indicator language’ has to be spoken when joining the ERA (the European Research Area).

Table 2. Dissemination of OECD methodological knowledge in CEECs, Year of publication in the national language

Countries	FRASCATI	OSLO	TBP	PATENT	CANBERRA
	MANUAL				
Bulgaria					
Czech Rep.	Auth. '94				
Estonia	Auth. '99 S)				
Hungary	1996 (T)	1996 (T)	1995 (S)	1998 (S)	1999 (T)
Latvia					
Lithuania					
Poland	Auth. '95	Auth. '99			
Romania					
Russia	1995 (T)	1998			
Slovenia	Yes				
Slovakia	Yes				
Ukraine					

Notes:
T = translation
S = summary
Auth. = authorized

Sometimes there are too many figures with too little information and the indicators are far from up-to-date. In several countries there exist only weak connections between indicators and analysis. Such weaknesses may result in policy-makers neglecting to use indicators and, instead of indicator capacity-building, investing in 'fast indicators' to justify their decisions.

Both users' and producers' capacities have to be increased together. Parallel and interactive actions are vital for the development of good indicators, appropriate analyses and for the support of policy-making decisions. The quality of other policy-making instruments is also dependent on the availability and reliability of indicators.

B. Upgrading the intellectual capabilities for S&T and innovation policy-making in CEECs. (CIPRE)

Most of the transitional countries lack the institutional capability for sophisticated policy making on S&T and innovation and for building consensus among policy makers, corporate decision makers and members of the research community on S&T and innovation policy issues. Recognising the lack of capacity in modern S&T policy making the Science Policy Directorate of American Association for the Advancement of Science (AAAS) and Innovation Research Centre (IKU) Budapest University of Economic Science and Public Administration established the Centre for Innovation Policy Research and Education for Central and Eastern Europe (CIPRE) in Budapest in 1999. The event was a satellite seminar to UNESCO-ICSU World Conference on Science.

CIPRE is an international, English speaking, joint program of IKU, BUESPA and AAAS, that is intended to serve several important purposes:

- It provides a setting for researchers and policy makers from the nations of Central and Eastern Europe to pool their resources, expertise, and knowledge to advance the state of science, technology and innovation policy in this region.
- It provides a mechanism through which scholars and practitioners from the European Union, North America, Japan, and other industrial nations can share their expertise with colleagues and students from the CEE nations.
- It serves as means of disseminating the latest and most advanced ideas and methods in S&T and innovation policy throughout the nations of Central and Eastern Europe.
- It helps researchers and experts in the CEE nations overcome their isolation and reach the critical mass necessary to offer a high-quality training programme for mid-career people as well as graduate education at the Master's and PhD levels.
- Finally, it also helps to strengthen up-to-date thinking on policy matters, and to develop advanced knowledge management capabilities.

One of the tools that may help the modernization of S&T and innovation policymaking in Central and Eastern Europe is the training and retraining of policy-makers, knowledge and innovative managers. The overall goal of CIPRE's seminars is to advance the state of the art of science, technology, and innovation policy in these nations through the development and cultivation of human resources.

The series of CIPRE Seminars are designed to support mutual learning and understanding, as well as networking. The dual aims of networking are advancement in regional co-operation and integrate CEECs sufficiently into the international scientific community. The key feature of seminars is the information dissemination. They provide the relevant information back up for decision-makers and analysts to perform their tasks and develop their lateral ties of institutions as recipients.

Trainers, trainees, mentors and sponsors

Trainers:
Trainers are excellent professionals from several countries on each seminar. Different national experiences and good practices are crucial to be disseminated through the involvement of CEE high-ranking decision-makers in panel debates.

Mentors:
This program is modelled on the AAAS Science and Engineering Policy Fellowship Programs which have been in operation in the U.S. since 1973. This model has been adapted to multi-country and multi-lingual environment.

Mentors are present and former S&T policy advisors to strategic decision- makers, high-ranking state administrators and senior researchers involved in policy advisors' tasks. They are responsible in their own countries for working with CIPRE trained young and mid-career people to assist in their professional development following the seminars.

A mentor need not know the answers to all the questions, but he/she has to be able to show the way to get these answers. They need a helping hand, because they are wavering about a lot of things (for example how to give a speech, etc.). The mentor should help at further seminars as well: increasing the quality, organising, finding good applicants.

The mentors have several different tasks to support both CIPRE and upgrading the national capabilities:
1. Nominate participants for the seminars, to promote good quality selection,
2. Help the trainees, contact them personally, directly, and help them to find their role in the program,
3. Keep in touch with the organisers, to give them feed-back, to ask them questions,
4. Come back together in 2-3 years to discuss the results and responsibilities,
5. Suggest topics for future seminars and courses.

Trainees:
The best candidates for seminars are those, who has already involved in S&T and policymaking, either as decision makers or advisors. The trainee should show potential benefits in the future as a result of the present activity. The candidate has to be fluent in English (at least passive level).

Some of the potential client organizations whose employees might be interested in the CIPRE training courses are listed below:
1. Governmental bodies of S&T and innovation policy (legislative and executive branch offices). These bodies are different by countries. In many countries such type of institutions are involved in S&T and innovation policy making: Ministry (or agency) of S&T, Ministry of Economic Affairs, Ministry of Education, Ministry of Agriculture, Ministry of Healthcare, Ministry of Environmental Protection, Ministry of Transport and Communication, Ministry of Defence, Ministry of Jurisdiction (Law making), Ministry of Foreign affairs, Contact organisation to international organisations (e.g. EUREKA, EU, OECD, NATO), Prime minister (or equal) office/council of S&T policy.
2. Elected governmental bodies: Committees and sub-committees of Parliaments, staff members of Parliament offices, Regional governing bodies.
3. Non governmental organisations: Universities technology transfer offices, research administrations, liaison offices, Personal societies.
4. Infant for-profit organisations: Innovation incubators, Industrial parks, S&T, technology transfer service providers.

These organisations might delegate a broad variety of trainees to CIPRE programs:
- Present young and mid-career S&T policy advisors to strategic decision- makers.
- Middle-ranking state administrators.
- Foundation managers.
- Managers of supporting organisations of high-tech SMEs.
- University professors, researchers.

CIPRE Activities

Preparation phase:
1 Day seminar towards CEE-IKU 1: “Establishing a Central and Eastern European Innovation Research Centre (CEE-IKU)".

Washington D.C., in June 1998
Support: NATO Science Program
Number of participants: near 30
Topic: American experts in S&T policy-making from different organizations and Hungarian attaché

3 Day workshop towards CEE-IKU 2: "Transformation of Innovation Systems in Transition and Newly Industrialised Economies" and discussion of a proposal ”Establishing a Central and Eastern European Innovation Policy Research Centre”.
Budapest, in June 1999
Support: Hungarian Academy of Sciences, OMFB (National Committee for Technological Development, Hungarian Foundation for Industry (IMFA) and voluntary work.

Number of participants: near 50 participants from 14 countries and organizations
Topic: The workshop on „Transformation of Innovation Systems" was an official satellite event of the UNESCO-ICSU World Conference on Science. Besides discussing various subjects relating to innovation the workshop's participants discussed a proposal "Establishing a Central and Eastern European Innovation Policy Research Centre".

3 Day Advisory Board Meeting with the invited participants representing government agencies, universities, and academies of science in the CEE nations to assess the interest of CEE nations in a range of topics under the general heading of S&T, and innovation policy for training seminars to set priorities for CIPRE's future activities.
Budapest, in June 2000. Working name of the center CEE-IKU was replaced by a new one: CIPRE.
Support: NATO Science Program and voluntary work.
Number of participants: 24 from 14 countries
Topic: Board as well as Participants agreed that CIPRE should give highest priority to cultivating policy leadership through educational programs for early and mid-career professionals, including short courses, summer workshops, and policy fellowships.

Working phase:
2+3 Day Seminar for National Contact Points in conjunction with a meeting of the MESIAS Network, a network of the STRATA program within the Fifth Framework Program of the European Union, with the title "The Upgrading of Absorptive Capacities of Domestic Firms and Institutions" and participants also discussed the program of the CIPRE training seminar series.
Budapest, in March 2001,
Support: CEE participants were partially supported by UNESCO, Hungarian Science and Technology Foundation (TéT Alapítvány) and by R&D Directorate of the Hungarian Ministry of Education and voluntary work. Members of MESIAS Network were granted by EU.
Number of participants: about 51 people from 18 countries (34 CEECs, 15 EU member countries and representatives of EU and UNESCO)
Topic: "The Upgrading of Absorptive Capacities of Domestic Firms and Institutions" The participants discussed the shaping of science and technology policy by governments, with special attention to funding and budgets for R&D. They also discussed the training seminar program recommended by Advisory Board and set up the orders of seminars, the role of mentors, and identified the joint research interests.

Launching the MENTOR Program
The purpose of these meeting is to engage the mentors, assure their commitment to CIPRE training program, and provide them with the background they need to participate successfully.
3 Day seminar for potential Mentors (STI Policymakers and Administrators) to prepare the mentors for their continuing roles.
Budapest, in November 2001
Support: NATO Science Program, UNESCO and Hungarian Foundation for Industry and voluntary work.
Number of participants: 15 mentors (19 participants' altogether)
Topic: "Mentor Seminar for STI Policymakers and Administrators" was a special seminar to prepare the mentors for their continuing roles. The workshop was organized around three main scientific issues: 1) Policymaking tools, including technology foresight and indicators. 2) Internationalisation of S&T Policy making and participating in EU scientific programs, co-operations. 3) Mutual understanding and learning from each other.

Launching the Mid-Career Training Seminar Program
CIPRE is organizing a series of seminars for young and mid-career professional in science, technology, and innovation policy in the CEE countries.
12 Day 1st Young- and Mid-Career Training Seminar on "The Changing Role of National Governments in STI Policy Making in the Age of Globalisation and Regionalization".

Budapest, in January 2002
Support: NATO Science Program and voluntary work.
Number of participants: 22 people from 14 CEE countries
Topic: "The Changing Role of National Governments in STI Policy Making in the Age of Globalisation and Regionalization". The seminar was organized as a series of lectures and exercises with the active participation of specialists from Western and CEE countries. The lectures were grouped in clusters on different interrelated topics: System of Innovations and Modern Policy-making – Interactions around core actors and key tools, policies in practice.

Forthcoming:
10 Day 2nd Young- and Mid-Career Training Seminar on "Policy Analysis and Implementation".
Budapest, in November 2002
Support: NATO Science Program, UNESCO, Hungarian Foundation for Industry (IMFA), Soros Foundation (to be confirmed) and voluntary work.
Number of participants: expected about 25 people from 17 CEE countries
Topic: "Policy Analysis and Implementation". List of the planned topics: 1) Relationship between S&T and innovation policy and other policies. 2) Policy measures. 3) Understanding the challenges of internationalisation. 4) Changing role of the core institutions of the innovation system. 5) Transmission of knowledge, mobility of human resources, "brain drain," "brain gain," "brain circulation."

10 Day 3rd Young- and Mid-Career Training Seminar on the "Roles of the different actors in the policy and decision-making processes".
Bucharest, in April 2003
Support: NATO Science Program
Number of participants: expected about 30 people.
Topic: "Roles of the different actors in the policy and decision-making processes". The Seminar will deal with the following issues: 1) Division of labour and co-operation among legislative and executive governmental agencies. 2) International organisations: relevant EU offices (EU Parliament, EC Departments, EU Programs), EUREKA, NATO. 3) Opportunities for professional organisations, associations to participate in policy shaping: business associations, interest groups, professional scientific organisations, S&T community.

Table 4: Countries have been involved in CIPRE seminars between June 1999 and January 2002

CEECs		EU countries		Americas		Others	
Albania	2	Denmark	1	Brazil	1	EC	1
Bulgaria	4	France	1	Canada	1	OECD	2
Croatia	2	Germany	2	US	15	UNESCO	1
Estonia	4	Great Britain	4				
Czech Republic	2	Greece	3			Australia	2
FRY Montenegro	2	Italy	2			Egypt	1
Hungary	49	Norway	2			Japan	1
Latvia	1	Portugal	1			Russia	1
Lithuania	5	Spain	3				
Moldavia	2	Sweden	1				
Poland	9						
Rep. of Serbia	5						
Romania	11						
Slovak Republic	2						
Slovenia	3						
Ukraine	7						
Together	110		20		17		9

Launching Internships

CIPRE intends to play an active role in facilitating internships and fellowships for S&T policy practitioners, scholars, and students from the CEE countries to study and work in the European Union, North America, and at other technologically advanced nations.

Table 3: Facilitating Internships and Fellowships

At AAAS	At IKU/BUESPA
Rossitsa Chobanova (Bulgaria) NATO Internship for 3 months	Igor Yegorov (Ukraine) NATO Internship for 3 months
Fatos Dega (Albania) NATO Internship for 5 month	Nodar Pakhalaedze (Georgia) NATO Internship for 1 month

Sponsors of at least 1 project:

- NATO Science Program,
- UNESCO Science Analysis and Policies,
- Hungarian Foundation for Industry (IMFA),
- Hungarian Science and Technology Foundation (TéT Alapítvány), and
- R&D Directorate of the Hungarian Ministry of Education.

Who else?

Publicity and Publications:

For detailed information on the CIPRE program please visit our website: http://www.cipre.org

Publications emerging from the results of CIPRE activities:

Dega, F. 2002: The State of the Albanian Science System and Problems of its Development, Albanian Journal of Natural &Technical Sciences, Nr. 9/2000 pp. 153 – 159, Tirana, and www.cipre.org forthcoming

Inzelt, A. and L. Auriol (eds.) 2002: Innovation in Promising Economies, Aula, Budapest, Hungary

Pastushenko, S. 2002: Ukraine – S&T policy overview, www.cipre.org forthcoming

Teich, A. and A. Inzelt: "Strengthening Innovation Policy in the Transitional Countries of Central and Eastern Europe" presentation at the 4th Triple Helix Conference, 6-9 November 2002, Copenhagen, Denmark

Publications on CIPRE activities:

Csonka, L. 2002: "Conference reports: CIPRE Mentor Seminar for STI Policymakers and Administrators", Acta Oeconomica, Vol. 52 (2) pp. 262-264 (2002), Akadémiai Kiadó Rt., Budapest

Csonka, L. and M. Fertetics 2002: Report for UNESCO on the CIPRE Mentor Seminar for STI Policymakers and Administrators www.cipre.org/mentor.html and www.unesco.org/pao/events/events.htm

Inzelt, A. and A. Teich 2000: "CIPRE" at Global Development Network Conference, December 2000, Tokyo, Japan, poster presentation.

Yegorov, I. 2002: Report on 1st CIPRE Mid-career Training Seminar, www.cipre.org forthcoming

Future Plans:

1. Launching regular (bi-annual) forum on science and technology policy issues in Central and Eastern Europe modelled on the Annual AAAS Colloquium on S&T Policy. Symposium topics would include budgeting and organization of S&T in the CEE countries, science advisory mechanisms, and participation in international cooperative ventures.

2. Locate each odd seminar outside Budapest in different CEECs to increase the participation from Eastern European countries. Meetings in various countries can help to include more important decision-makers from the host countries.
3. CEE S&T&I Policymaking Manual

Fundamentals of S&T Policy (A Collection of Readings and Exercises)

Most of the people who are entering these programs are not S&T professionals, most they have never worked in policy-making, and because there are no S&T or policymaking courses at colleges, high schools or universities, CIPRE courses have an important role. These new, young people need to have a guide, who will show them the way, how to get the new knowledge they need, how to adopt the best mentality and attitude. Policy Making Manual can serve directly CEECs needs. Most of the participants think a 'tailor-made' manual would be very useful for this young generation to learn the basic knowledge.

It has to find out which parts of different S&T policy approaches and methods could be useful for the very inhomogeneous Central and Eastern European countries. According the provisional outline of manual it has to cover the following topics:

1. The changing role of national governments in policy making in the age of globalisation and regionalisation
    - Public policy activities, shaping and managing policy, process of priority setting
    - Budgeting S&T and innovation, policy programs and R&D budget
    - Facilitating and managing S&T and innovation policy, international co-operation
    - Encouraging and regulating foreign (multinational) investment in S&T and innovation
    - International relations in scientific and technical subjects (bi-national and multinational co-operation)
    - Public-private relationships and government-industry-university partnerships in S&T

2. Policy analysis and implementation
    - Relationship between S&T and innovation policy and other policies (such as economic, competition)
    - Policy measures (tax incentives for business, grants to higher education, including strategic grants and partnership programs, grants to employ recent graduates)
    - Understanding the challenges of internationalisation (global sources and local performance)
    - Social and private rates of return on investment in R&D
    - Changing role of the core institutions of the innovation system: government laboratory activities, higher education, business
    - Human resource development (higher education, training incentives, lifelong learning, distance learning). Use of absorptive capacity and knowledge management
    - Transmission of knowledge, mobility of HR, brain drain, brain gain, brain circulation

3. Roles of the different actors in the policy and decision-making processes
    - Division of labour and co-operation among legislative and executive governmental agencies, including the role of Parliament, its committees, and advisory bodies
    - International organisations: relevant EU offices (EU Parliament, EC Departments, EU Programs), EUREKA, OECD, NATO, relevant UN organisations such as UNESCO
    - Opportunities for professional organisations, associations to participate in policy shaping: business associations, interest groups, professional scientific organisations, S&T community

4. Policy Tools

4.1 Relevant, internationally comparable up-to-date indicators as tools for policy making.

- Statistical measures for science, technology, and innovation
- S&T and innovation indicators (input, output and outcome)
- The role of data producers and users in the S&T information system
- Patent indicators as measures of R&D performance, innovative capabilities
- Evaluation and performance indicators employing measures of activity, linkage, impacts and outcomes, both at the ministry level and across government
- The use of indicators in public policy; the role of national statistical offices and international organisations (Eurostat, OECD, UNESCO) in producing and employing indicators

4.2 Recently emerging tools

- Priority setting mechanisms
- S&T and innovation budgets analysis
- Evaluation: programs, projects, research units, institutions, individuals
- Audit of technologies, sectors
- Roadmaps and foresight
- Risk assessment (health, environmental and economic aspects)

5. Intellectual Property Rights for development

- Adequate legal frameworks and institutions for intellectual property rights. Brief overview on the history of IPR system – international conventions. The institution of intellectual property, the international IP regime
- Law on IPR. (patent law, trade mark, protection of industrial design, geographic origin, copyright) Role of national and international Patent Offices
- Build up, develop and modernise IPR system. The influence of legal frameworks for intellectual property rights on international trade and technological development
- Mechanisms for commercialisation of IP in higher education and in government
- IPRs and their enforcement as part of national innovation system. Tacit versus codified knowledge, availability of codified knowledge. Foreign investment and character of the IPR legal system, enforcement of IP laws
- Commercialisation of indigenous, accumulated knowledge, intellectual property developed in universities and the IPR legal system. Impact of IPR s on business R&D investment, business and university R&D co-operation

As it is known from the literature several textbooks, guidance contains many of these topics. New manual has to provide the essence of this knowledge including many examples for practitioners. There was agreement about the harmonisation of lectures and examples of Western-, Central and Eastern Europe and North America. Of course CEECs must have a look at the Western examples, but we have to try to find the balance between the Western and the Central and Eastern problems and solutions. The main role of the EU is to provide and share their ideas with us.

- **Summing up the initial years' experiences it may state that CIPRE is playing an important role in building and strengthening S&T&I policy-making capabilities in CEE.**
- **Many voluntary works have been included in the first findings of CIPRE. The majority of organisational and program development work have done voluntary by co-directors and some of the advisors.**
- **National contact points and mentors are also working on voluntary basis. Many lecturers have worked for CIPRE as volunteers.**
- **Because CIPRE has grown up it has reached its limits to work on regularly voluntary basis.**

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2.4 The relevance of the big countries: R&D, Innovation and Productivity Growth: Some thoughts on the Barcelona Objective

Yannis Katsoulacos, Athens University of Economics and Business

1. Introduction - Background

In March 2000, at the Lisbon European Council, Heads of State and Government set the European Union the goal of becoming "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" by 2010. Two years later at the Barcelona European Council, which reviewed progress towards the Lisbon goal, they agreed that Research and technological Development (R&D) investment in the EU must be increased with the aim of approaching 3% of GDP by 2010, up from 1.9 % in 2000. They also called for an increase of the level of business funding, which should rise from its current level of 56 % to two-thirds of total R&D investment, a proportion already achieved in the US and in some European countries. The 2002 Broad Economic Policy Guidelines of the Member States and the Community acknowledge the importance of this goal and recommend **to improve incentives for firms to invest in R&D** while preserving sound fiscal policies.

According to a recent CEU Communication dealing with the Barcelona objective "[The] R&D investment objectives set at Barcelona arise from the recognition that strengthening European R&D and innovation systems is essential in realising the Lisbon strategic goal".

Now, overall expenditure on R&D as a share of GDP has risen since the 1980s in most OECD countries mainly reflecting increases in R&D activity in the business sector. Indeed the share of publicly financed R&D has declined over the past decade in most countries as a result of reductions in military R&D budgets. Nevertheless, comparison of R&D expenditure in the EU and in the US shows a massive and rapidly growing gap. R&D intensity in the EU, stagnated at around 1.9% over the last ten years, while in the US it grew continuously from 2.4 % in 1994 to 2.7 % in 2000. The bulk of the R&D gap (more than 80 %), and most of its increase in recent years, is due to lower funding by the EU business sector. In addition, the US government devotes almost a third of its R&D funding to support business R&D, compared to only half that share (16 %) provided by public funding in the EU. The leverage effect of this substantial and sustained government support in the US is one of the factors contributing to the rise of business-funded R&D in the second half of the 1990s.

The role of R&D as a driving force for a competitive economy is linked to R&D investment been an investment in knowledge that translates into new technologies as well as more efficient ways of using existing resources of physical and human capital (innovations). The consensus opinion from a multitude of empirical studies over more than two decades is that R&D has a persistent effect on GDP, competitiveness and productivity growth, that is, higher R&D expenditure would, ceteris paribus, be associated with permanently higher growth rates.

The role of innovation in competitiveness has been stressed in the recent Global Competitiveness Report for 2001 of the World Economic Forum and the Harvard Centre for International Development (see also http://www.project-syndicate.cz/series/"htttp://www.weforum.com) in which "competitiveness" is defined «as a country's capacity to achieve sustained economic growth in the medium term – i.e., five-years time»[2].

[2] As mentioned in the report, Finland, USA and Canada were in the first, second and third position respectively among the 75 countries that were evaluated.

As noted by one of the report's main authors, Harvard Professor Jeffrey Sachs «in this year's rankings, we determined a country's competitiveness (the capacity to grow) according to three broad criteria: (1) **technology**; (2) **public institutions**[3]; and (3) **macroeconomic stability**[4]. Indexes were created in each of these categories and then averaged in a specific manner to create an overall Growth Competitiveness Index. Technology refers to the ability of the country to spur new inventions and to adopt technologies invented in other countries. Some countries, like the US, Japan, Korea, Israel, and Sweden, invest heavily in research and development, and so achieve high rates of innovation. Other countries, like Argentina and Brazil, invest less in research and development, and therefore achieve little in the way of new products and processes. Innovators enjoy a high level of prosperity as the result of their innovations. Here the US, Canada, and Finland rank 1st through 3rd.

In our competitiveness studies, we noticed that the world economy can be divided into two categories of countries: the innovators and the non-innovators. Only about 20 countries in the world are active creators of new inventions. For these countries, which tend to be among the world's richest, continued competitiveness requires an excellent system of technological innovation.

Universities must be excellent, government laboratories should be world class, and government and industry should be investing heavily in research and development. A key determinant of future growth among these economies is the proportion of students that go on to higher education after high-school graduation. This proportion is now around 80% of students in Canada and the US.

For "non-innovators," technology remains important, but in these countries most new technologies are imported from abroad rather than invented at home. Some of these countries are good at importing new technologies, and others are not. For the past decade or more, a great deal of technological imports came in the context of foreign direct investment. When American firms invested heavily in Mexico, or Taiwanese firms invested heavily in mainland China, the firms brought with them new technologies that upgraded the production efficiency of the host economy. So it made sense for countries to compete vigorously for such foreign investors: they offer not only capital, but also new technologies».

2. The Policy Challenge

2.1 The Barcelona objective translated in terms of the required increase in R&D investment

As far as average Business Expenditure on R&D (BERD) intensity (BERDI = BERD/GDP) in EU15 is concerned the Barcelona objective is to raise this from 1,1% to 2% or by about 82% from its current level. However the increase in BERD must be quite a bit higher than that since as BERD increases this raises GDP and the latter is also going to grow independently of increases in BERD. Empirical evidence suggests that the private rate of return to R&D investment, that measures the effect of R&D intensity on GDP growth, is about 25% (depending on the study the estimate ranges from 15% to as high as 50%).[5] Assuming an independent (non-R&D induced) growth in GDP of 16% between 2003 and 2010 (about 2% per year), it can be shown that to satisfy the Barcelona BERDI target, BERD has to grow by about 7,5% per year. However,

[3] Public institutions refer to the quality of governance. Is there widespread corruption? Are courts honest and impartial in their judgments? Can governments be trusted to follow through on their commitments? Countries with well-functioning public institutions achieve higher rates of economic growth than do countries plagued by corruption and rotten judges. High ethical standards promote better economic performance. Northern Europe stands at the top of the world in this regard, with Finland, Iceland, and Denmark ranking 1st through 3rd. Corruption is deemed nearly non-existent in these countries.

[4] Macroeconomic stability refers to the absence of inflation, budget balance, a realistic value for the exchange rate, the ability of businesses and government to obtain market loans, and high confidence that government financial obligations will be honoured. We have learned in the past decade that even when businesses are internationally competitive, a macroeconomic crisis can derail economic growth, as it did in most of Asia in the late 1990s. Singapore, Ireland, and Switzerland are the three top-ranked countries in macroeconomic stability.

[5] See excellent survey of Grilliches (1995) and recent papers of Bassanini et.al (2001) and Guellec et.al. (2001).

over the 1990-2000 period BERDI has grown on average by slightly less than 2% per year (Sheehan, OECD, 2002)[6]. This gives a good idea of how formidable is the task set by the Barcelona objective.

2.2 Policy Measures

The point is that the consensus concerning the positive impact of R&D investment on productivity growth is matched by an equally broad consensus that there are many market failures in the R&D investment activity. This implies that, in the absence of any policy measures, R&D is not likely to be at the social optimal levels. This can justify government involvement in R&D, both through direct provision and funding, but also through indirect measures such as tax incentives, protection of intellectual property rights and improvement of other framework conditions to encourage private-sector R&D. Such government involvement has been the rule in most countries for many decades. The implicit assumption behind setting the Barcelona objective and in the Communications following that, is that policy measures in Europe in the past have been either inadequate or of the wrong type (or both).
Below we classify measures into two categories: measures that improve framework conditions and financial incentives.

A. Measures that improve the Framework Conditions

Measures that are designed to improve the so-called framework conditions, aim at creating an environment, which is more conducive to research and innovation. This is the environment that determines the availability, quality and cost of the resources that are used in the innovation and R&D process, as well as the appropriability and competitive conditions of firms, that determine their expected returns from investing in R&D.

It includes:

- The extent to which markets (product, labour and financial) function in an efficient way (and, within the financial markets, the maturity and effectiveness of Venture Capital institutions)
- The cost, availability and quality of the infrastructure, of the human and physical capital AND of the knowledge flows from “basic research” that are used as inputs into innovation activity (and are responsible for the generation of technological opportunities).
- The institutional and policy framework that determines conditions of education, of public investment in R&D, of University investment in R&D, of investment in infrastructure and the “easiness” with which public/university knowledge flows to the private sector. These factors are of course also critical in influencing the location of R&D activity.
- The availability, density and interconnectedness of vertically and horizontally related industries, which generate positive externalities both from knowledge spillovers, transactional efficiencies, and cluster-level scale economies, which are enhanced when clusters are concentrated geographically (Furman et.al., 2002).

B. Direct and indirect financial incentives

Direct financial measures address companies directly and offer them public funds that are expected to individually or collectively motivate them to undertake more research. The most popular schemes under this category are variations around the research grant to firms. Indirect measures, mainly tax credits or exemptions, address the same need, to reduce uncertainty, by different means. Their main advantage is that they provide companies with an incentive to increase R&D spending while leaving the decisions on individual

[6] To achieve the GERD intensity target GERD has to grow by slightly less than 7% per year an equally daunting task given historical growth rates of about 2%.

projects in their own hands. Among the G7 countries all countries except Germany (which has some regional measures but no national credit scheme) use some form of R&D tax credits[7] (that is, Canada, France, Italy, Japan, UK and USA), all of them, except Italy, for both large and small-medium enterprises.

3. The Fundamental Barcelona Policy Objective: some country level policy issues

It is obvious from the discussion above and the Council statements that the fundamental objective in raising the R&D intensity (RDI[8]) is to increase innovation and thus promote competitiveness or sustainable GDP per capita growth in Europe. It follows, and I will assume, that in choosing policies to raise RDI the main criterion must be the impact of the policy on innovation and GDP per capita growth. We can, in order to facilitate the discussion, formalize the relation between, say, innovativeness or productivity growth and RDI in a country as follows:

$$PG = f(RDI(x); X) \qquad (1)^{9}$$

Where
PG = productivity growth (I use this rather than an index of innovativeness (INN) since PG is more general: it includes innovativeness but also improvements in efficiency that are not innovation-induced[10])
x = vector of factors that affect RDI[11]
X = vector of factors that can affect PG independently of RDI

Note that x and X have many common elements: most factors that affect PG (or, INN) directly (i.e., for given RDI, and so are included in X) – e.g. conditions of competition in product markets, education or basic research - will also affect RDI (so are included in x) and thus will affect PG indirectly through their effect on RDI. On the other hand, there are factors (e.g. tax credit policy) that are included in x but not in X.

Clearly, the optimal policy mix in terms of policy measures for raising RDI in Europe should be guided by theoretical and empirical research that characterizes (1) – research that specifies on the basis of theory what factors should be included in x and X, and then estimates empirically the relative statistical significance of these various factors. However, it is obvious that the optimal policy measures mix will differ from country to country and even from region to region in Europe. As the CEU Communication mentioned above notes "…….it is recognised that the diversity of situations in Member States and Candidate Countries must allow for a differentiated policy response". Still a question that emerges is: if actions can also be agreed and launched at European level is there a best way of targeting countries in order to maximise the impact of policy measures on average EU GDP per capita growth?

We should immediately note that it is unlikely that the objective of maximizing average GDP per capita growth in EU15 is acceptable given the pursuit of convergence in GDP per capita. That is, what we want is to maximize average GDP per capita growth subject to a reduced - inequality constraint. Convergence requires that countries, with lower GDP per capita than the EU average must catch-up to the rest, and we need to see how this is related to the satisfaction of the Barcelona objective. Whilst the Lisbon objective is to improve competitiveness and growth in Europe it is stressed that the achievement of this objective has to be set in

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[7] The form differs depending on whether it is directed to SMEs or large firms or both and on whether an incremental scheme (based on a company's additional R&D activity) or a volume scheme (based on a company's total R&D activity is used.

[8] Throughout we use RDI to indicate R&D intensity or R&D capital stock intensity, depending on the context. The latter concept is the one used in by far most empirical studies relating R&D to productivity growth.

[9] A similar equation can be written using GDP per capita growth rather than INN or PG as the dependent variable.

[10] We will use PG as a catch-all term to indicate a number of productivity growth measures used in empirical research – the most popular been multi-factor (or, total factor) productivity (MFP or TFP) growth.

[11] Strictly speaking we should have used RDCI = research and development **capital** intensity, which is also the variable used in most empirical studies – or we could be thinking of RDI as a vector of R&D intensities of the current and previous years appropriately weighted to allow for the depreciation of R&D capital stock.

the context of convergence between member states. This must be carried into the discussion on R&D: if research intensities converge this greatly facilitates the convergence in incomes. To put in another way, unless research intensities converge the task of convergence in income becomes much harder to achieve.

Let us nevertheless start by considering for a moment average European GDP per capita growth and how it can be maximized through appropriate selection of European countries which are targeted for raising their Research and Development capital intensity (RDI). An important thing to note here is that empirical evidence is consistent with the existence of non - decreasing returns in investment that increases the R&D capital stock - in the specific sense that countries with a high R&D capital stock intensity may gain more in terms of productivity growth from further raising this intensity than countries with low R&D capital stock intensity.

The evidence for the existence of non-decreasing returns is mostly indirect as econometric studies do not usually attempt to test directly for the existence of diminishing returns (non-linearities in the R&D term) – a recent paper that does so (Griffith et.al.,2001) concludes that there is no evidence for diminishing returns. So, for example, Grilliches (1995) reports that in general empirical studies at firm level do not show a decline in the relevant R&D coefficients measuring private returns to R&D over time. Also he notes that empirical studies at industry (sectoral) and national levels indicate the existence of sizable externalities (spillovers) from R&D investment – a source of increasing returns – leading to large positive differences between social and private returns to R&D. In the recent OECD study by Guelec et.al. (2001) the authors find that business R&D capital stock seems to have a growing impact on multi-factor productivity growth over time, and that a country's business R&D capital stock intensity has a positive effect on the size of the long-run elasticity of GDP growth to business R&D capital stock intensity. As they conclude: "This finding points to some kind of increasing returns from investment in research. By spending more on R&D, businesses in a country are able to reap internal economies of scale, to set up networks, to benefit from each other's discoveries. It also denotes an improved ability to absorb the domestic knowledge generated by other firms and/or industries".

These results suggest that the maximum impact on average GDP per capita growth by raising average EU RDI in EU15 could be achieved by *concentrating on measures that raise the RDI of countries in which RDIs are already very high.* Given however that the percentage of EU BERD accounted for by the "small countries" with high RDI (Sweden, Finland, Netherlands) is very small (about 10% share in EU BERD) *the conlusion that emerges is that, to achieve the maximum impact on GDP per capita growth in EU15 by raising average EU RDI, the most effective way is to concentrate on measures that raise the intensities in Germany, UK and France* (they account for about 70% of EU BERD).

Coming now back again to the convergence issue, one can show that this policy approach may not be very bad even if convergence considerations are taken into account. This is because another empirical result is that the long-run elasticity of output growth with respect to foreign R&D may be even higher than that from domestic R&D (Guellec et al, 2001; see also Coe and Helpman, 1995, who also find large effects of foreign R&D on domestic total factor productivity[12]). This conclusion, indicating very large across-country spillovers, stems from the fact that in their sample of all OECD countries each country's share of the new knowledge generated by the group is quite small. However for this to hold, certain conditions must be satisfied. The main condition is that R&D intensities in the receiving countries are sufficiently high to allow these countries to benefit from foreign R&D: the impact of domestic R&D intensity on the elasticity of foreign R&D is positive and significant (even though existing empirical research has not determined what exactly is the R&D intensity in the receiving country that will allow it to achieve substantial benefits from foreign R&D, this is unlikely to be less than 1%). As Guelec et.al. (2002) note "other countries' R&D (may) matter more than domestic R&D for the purposes of productivity growth, provided that the country has the capacity to absorb technology from abroad".

[12] Also, Eaton and Kortum (1994) calibrate a model of international technology transfer and find that, even for USA, around half its productivity growth depends on foreign technology improvements.

Probably the most clearcut and forceful evidence of the positive role of R&D in improving absorptive capacity – the capacity to absorb technology from abroad – or, to facilitate technology transfer, and thus increase productivity growth can be found in the econometric study of Griffith et.al.(2001) in which the authors use panel data from industries in 12 OECD countries. The authors investigate the impact of R&D on total productivity growth at industry and country level through its impact on innovation and through its impact on technology transfer. They find that the latter effect is very important: it can even lead to more than doubling (from 43% to 95% - for Finland) the social return to R&D when measured in terms of its effect on innovation only. Of course, the impact of R&D on absorptive capacity depends on the distance of an industry from the productivity frontier: the further away it is the greatest the impact. The question that emerges is "why countries that are far from the productivity frontier do not spend more on R&D?" The reason must lie in the divergence between private and social returns: R&D spending by business depends on private return and this will be lower than the social return if technology transfer effects take the form of externalities. Also there may exist other market failures associated with the underdevelopment of financial markets and government policies (framework conditions).

Though not yet proven on the basis of a formal model the above empirical results suggest that:

i. Countries with a low R&D capital stock intensity cannot take advantage of the significant gains that can be realized by technology transfer, and
ii. These countries are likely to be "trapped" in a R&D under-investment equilibrium because of acute market failures associated with adverse framework conditions.
iii. In other words the above empirical results are consistent with a hypothesis that there may be a critical R&D capital stock intensity, say RDI_c, not necessarily the same for all countries, such that if country i's RDI is $RDI_i < RDI_c$, the returns on raising RDI_i in terms of the effect on GDP per capita (or PG) growth is much smaller than the returns when $RDI_i > RDI_c$.

All these lead to the tentative conclusion ***that to maximize average EU15 GDP per capita growth under the restriction of convergence (a reduced-inequality constraint) we must concentrate on the two extremes: by raising the RDI of the 3 countries mentioned above we maximize average EU15 GDP per capita growth and the (foreign) R&D spillovers to the rest of Europe; by raising the RDI in those countries, in which R&D intensities are so low that they cannot get the benefit of foreign R&D we make sure that we satisfy the reduced inequality constraint.***

The policy measures used in this two-pronged approach will of course differ substantially depending on the country they are directed. Thus the objective of raising R&D should be seen, especially for low R&D intensity countries, not just as a means of becoming more innovative, but also (or even mainly) in the context of raising the ability and efficiency of imitating and absorbing others' know-how. This has potentially important implications for the policy-mix that is used to achieve the research intensity objective: the kind of policies that aim to increase R&D as a pre-requisite for innovation is different from that which aims to raise the absorptive capacity of a country.

4. Conclusions

Convergence requires that cohesion and accession countries, with lower GDP per capita than the EU average must catch-up to the rest. The above discussion suggests that the convergence issue must be carried into the European discussion on R&D: if research intensities converge this greatly facilitates the convergence in incomes. To put it in another way, unless research intensities converge the task of convergence in per capita income becomes harder to achieve. This is especially so if one also takes into account that countries (such as Greece and Portugal) that score low in R&D intensity also score relatively low on many of the other important determinants of competitiveness and growth: macroeconomic stability, human and social capital, functioning of product, labour and financial markets.

How can the European Commission support this? In the same way as it supports convergence in incomes through its Community Support Programs (CSPs). That is, **it should either develop new type Community Support Programs for Raising R&D and innovation capacity – the conditions, that is, that improve the productivity of R&D – that will be directed to member states in which R&D intensity is very low, say, less than 1%, or it should re-direct the traditional CSPs towards supporting R&D and innovation at a scale much greater than is done at present.**

Chapter 3: Success stories for capacity building: major actors

3.1. Dealing with the innovation deficit and supporting research and development actions in the European Union: Review and Proposals

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Introduction

It is a well established argument that research, commercialisation of new knowledge and the development of innovative products and services are more important than ever in today's growing society and economy of knowledge. **The competitiveness of an economy largely depends on the ability of each economy's research and innovation system entities to co-operate and assist in strengthening the research potential**.

Today, it is a fact that **European economies are losing ground compared with the US economy,** which is their principal rival, since their productivity is increasing at a much lower rate, thus leading to low benefits and performance. The reasons behind this occurrence can be sought and effectively dealt by strengthening the research potential and forming a cohesive core of research and innovation in the European Union.

The research potential of an organisation plays a major role in determining its development, its influences, the creation and distribution of wealth and the securing of competitive advantages in the ever-changing international economic environment. By focusing on research, EU firms and economies can succeed in increasing productivity and consequently in achieving more rapid economic and social convergence.

The innovation and competitiveness deficit of Europe compared with the USA - Review and comparison of indicative criteria

According to research undertook by the European Commission [1, page 3], despite the improvements in EU performance, the competitive deficit with respect to the USA is constantly growing. During the period from 1996 to 2000, GDP per capita in the EU increased annually by 2%, employee productivity by 1.3% and employment by 1%. During the same period in the USA, GDP per capita increased by 3.4%, employee productivity by 2.2% and employment by 1.9%.

The major reason for this innovation deficit lies in the lack of dynamism in entrepreneurship in industry and management, the high level of unwillingness to invest in new technologies and the increased delays in a series of structural initiatives and strategic actions.

Moreover the evident innovation deficit of the EU with respect to the USA, translated daily into a multiple competitiveness deficit, is demonstrated by a group of separate quantitative and qualitative criteria and indices which affect the performance of entities (businesses, research institutes, universities) in the national innovation systems. Of these criteria and indices, the following stand out:

- High fluctuations in the performance of innovative actions developed between various EU member states and regions. [2, page 5]
- Among companies with an interest in technology, the USA is still more popular than other European member states for research activities and co-operation in technology issues outside their national borders. For example, between 1990 and 1995, 53.1% of patents resulting from research conducted by

European firms abroad were from the USA, compared with the mere 40.4%, which came from Europe. [2, page 6]

- When European companies choose to establish R&D abroad, they prefer the USA to any of the EU member states. [2, page 20]
- Despite the fact that the overall availability of venture capital has increased significantly in the European Union since 1995, there is an evident reluctance to invest in companies that are not well established (do not have a proven track record) or are less experienced in risk assessment and management [2, page 20]. The level of venture capital investment and absorption in Europe, expressed as a percentage of GDP, is still half of that in the USA.
- 44% of European innovative products and 26% of European innovative procedures originate from patents, while in the USA the respective figures are 52% and 44%. This is a clear sign that European companies produce fewer patents than their American counterparts. [2, page 25]
- Small and Medium Sized Enterprises (S.M.E.) lack internal resources and networks, which are necessary for access to the knowledge, skills, technologies and funds required for the development of innovations. Moreover, many institutional barriers and costs disproportionately affect SMEs. Almost 49% of enterprises, fear of the cost entailed in a patent-defence litigation is a significant deterrent to investment in inventions. [2, page 57]
- Compared to firms in the USA, European firms are slower to enter new markets, adopt new procedures and develop products and services. A factor serving to demonstrate this development is the degree of activity involving patents. As regards patent applications submitted by domestic citizens (patent activity) per 10,000 inhabitants, the figure for the 15-members of the European Union is only 1/3 of that in Japan and 1/2 of that in the USA. [3]
- Europe is characterised by a limited concentration of intangible resources – R&D, high skill levels – expressed as a percentage of value added to the construction sector (44%, compared to 53% in the USA). Moreover, it is also far behind the USA in the development of services using high-grade skills (38%, compared to 50% in the USA). [4, page 11]
- Business start-ups in the USA are more than three times greater in number than those in the EU (2.4% of adults in the EU compared with 8.5% of adults in the USA). [5]
- Despite the fact that the liberalisation of markets significantly improved the image of information and telecommunications technologies (the Scandinavian countries developed qualitative infrastructure networks comparable to those in the USA), both the quality and scope of EU services in this sector continue to fall short of those in the USA (on a scale of 1 to 100, with 100 standing for excellence - the score for the USA - the European average is 71). [6]
- In terms of percentage of economic output, the European Union invests fewer resources in R&D than the USA. More specifically, it spends approximately 1.9% of its GDP for this, compared with the respective 2.7% and 3% in the USA and Japan [7, page 2]. It is also worth mentioning that funds invested by firms in R&D amount to 40% of the level in the USA, expressed in per capita terms. [4, page 24]
- The labour force employed in R&D activities is yet another way of assessing investments in this sector. As regards the number of researchers per 10,000 persons in the labour force, less than 50% of Europe's researchers are employed in firms, the corresponding figure in the USA being 80%. [4, page 25]
- The level of after tax revenue affects the extent to which firms are able to attract, motivate and retain talented and skilled personnel. At the same time, it affects individuals' incentive to work, to acquire additional skills and to accept new responsibilities. The average employee in Europe profits less from each pay raise than his counterparts in other countries. [4, page 35]
- Firms or individuals that promote innovation in Europe are faced with more difficulties in the effort to justify and fund investments than in the USA. Moreover, compared with the USA, governments are less generous in their support of R&D. Public funding of business R&D by European governments amounts to 9%, whereas the corresponding USA figure is 15%. [3]

Also, from the data obtained from the annual established innovation survey [8] of the Directorate-General for Enterprise on a significant number of EU firms, the following useful conclusions and trends were highlighted:

- Locating and attracting the specialised personnel required for innovation is a real problem faced by every member state. Two out of every three business directors rate this as a very big problem, the average being 62, with 100 being the highest rating. [8, page 46,47]
- Directors that participated in the survey generally drew a distinctly negative picture as regards fiscal measures in support of innovation development. Approximately 8 out of 10 believe that their respective countries' tax systems do not sufficiently encourage the development of innovations in businesses. Agreeable exceptions to this particularly negative European trend were Ireland, the Netherlands and Luxembourg, where it is generally accepted that the taxation systems essentially support innovation actions. [8, page 66, 67]
- As regards the opportunities (latent) that can arise from the development of the European money markets and greater access to venture capital for funding innovations, the directors' reactions varied significantly between member states, but on average, the attitude observed was slightly negative (47 out of 100). [8, page 68, 69]

UNICE stance – The EU's innovation deficit generators

According to the Union of Industrial and Employers' Confederations of Europe (UNICE) [4, page 6] this deficit is due to a number of internal and external factors, with respect to the firms, such as:

- Less support in risk-taking, in entrepreneurship and in the adoption of new technologies, which are vital ingredients for success in innovation.
- An unfavourable balance of opportunities, pressures and incentives for innovative actions in the European market regarding products and services.
- The minimal resources (compared with other developed countries) allocated for the creation and dissemination of knowledge, particularly in the field of research and development.
- European educational systems are less successful than other countries in providing their citizens with critical/vital skills (in fields such as mathematics, ICT, etc.)
- The EU tax systems are one of the major obstacles for those involved in the development of innovations, entrepreneurship and business in general.
- The regulatory and fiscal frameworks inhibit the development of modern and fully productive workplaces.

From the above it is clear that the deficit faced by Europe in R&D and the generation of innovations is one of the key obstacles in the European Union's effort to compete successfully with the more competitive economies of the world.

Proposals to strengthen the research potential and correct the existing innovation deficit

Research and development as well as education and training now constitute key elements in the effort to increase competitiveness and strengthen economies both at a national and a regional level.

The relationship between research and industry is the foundation for the new economy. The brilliant economic performance of the USA in previous years emphasises the role played, as the principal guide to economic development, by the effective interaction between firms and public research in the effort to convert knowledge into innovation. [9, page 4]

The strong ties between firms and academics are also of vital importance for countries in the effort to attract, and keep in the EU, personnel talented in research and the commercialisation of new knowledge.

The economy of knowledge also requires greater willingness to embark on innovative actions, which are characterised by high risk, as well as special emphasis on the role that can be played by SMEs.

According to the Lisbon European Council, the European Union is now called upon to correct the innovation and competitiveness deficit in a direct and targeted manner in order for it to become a "leading economy of knowledge under conditions of full employment and social cohesion". In this effort it is necessary to place an emphasis on removing all existing obstacles and problems faced by all the entities within the innovation systems of the EU member states.

The role of governments

A series of economic factors that include the perception of market risks, the inability to obtain suitable funding, the lack of necessary information or skills, regulatory and institutional restrictions and organisational inflexibility within firms all have a negative impact on the development of innovative activities.

Governments should firstly help to change citizens' attitude towards innovation by increasing public information, in order to widely publicise the benefits derived from investing in research and to strengthen the ties between industry and the scientific community even more.

Special emphasis must be placed on assisting entrepreneurs in taking risks and on the development of innovative actions. One of the greatest problems faced by today's entrepreneurs in Europe is finding suitable risk capital to establish an economically viable business [10, page 7]. For this purpose it might be useful to adopt the basic strategies for improving the risk capital investment environment, which were given in a report [10, page 7 / Progress report on the risk capital action plan, COM (200) 658 final] to the Parliament and Cabinet on the implementation of the 1998 Risk Capital Action Plan and are as follows:

- Ease quantitative constraints on institutional investors, allowing for greater freedom in choosing the investment and also ensuring protection of the members and beneficiaries.
- Soften bankruptcy laws in order to give entrepreneurs a second chance and also safeguard the interests of creditors.

It is also deemed necessary to create more favourable market conditions by modifying the institutional framework, which delays the entry of businesses into the market, creates institutional uncertainty and increases development costs.

Moreover, as regards development in general and the dissemination of new knowledge and its propulsion towards rapid commercialisation, it is necessary to locate institutional models and practices that will promote co-operation between the public and private sector more effectively (where co-operation priorities are determined by the participants and not by the governments), will provide incentives to universities and research institutes in a more substantial manner for the commercialisation of projects, and will remove obstacles so as to encourage business participation in spin-off companies. Spin-off companies bridge the gap between research results and new innovative products and services and provide effective assistance in the creation of permanent ties between state-funded research organisations and markets.

It is believed that the establishment of suitable institutional frameworks for copyright ownership will also serve as a barometer of developments towards this end [4, page 30]. Governments should introduce clear regulations and guidelines, taking into consideration copyrights originating from state-funded research, while also allowing adequate autonomy to research institutes [9, page 5]. In addition, research into the implementation of compulsory specialist arbitration [2, page 57], is deemed useful as the only effective solution to crippling costs [10, page 7] arising from patent-defence litigation.

Furthermore, it is essential that the education provided in mathematics, the sciences and ICT be improved, and that schools, universities and research institutes liaise with businesses, so as to create a well - trained, readily available labour force. Emphasis should also be placed on providing support to every social group participating in lifelong training programmes.

At the same time, in order to ensure that the public is well informed, governments should provide adequate public access to knowledge derived from state-funded research. Additionally, it would be useful to completely modify the regulations of Universities, which many countries have proceeded to do, in order to render the effort to establish ties between universities and industry more flexible. Courses will have to be modified so as to include different fields and various contacts with industry at the level of education and training. In the same context, governments should develop all the tools and information required to monitor the ties between industry and science and to assess their effectiveness, particularly by further developing indices and comparative evaluation methods at an international level.

In order to prevent the further disempowerment in science and research of many European governments, a cohesive framework of incentives needs to be developed (with substantial support from universities and research institutes, access to a wide range of research institutes and businesses and the creation of more networks, etc.) as an offset to the equivalent benefits in the USA. In order to encourage greater mobility of the specialised labour force and the return of emigrant scientists [9, page 26] within Europe and from non-member countries to the EU, various obstacles (issues concerning education and degree recognition between EU member-states, etc.) must necessarily be removed.

In an attempt to facilitate financing and the absorption of risk capital, it is considered necessary to encourage a raise in seed capital finance so as to create new spin-off companies, as well as the to reduce the total amount of taxes imposed on the business sector and investors. At the same time, governments are obliged to work harder to encourage private investments in research, focusing on the reduction of taxation levels, as the main obstacle for the absorption of venture capital (creation of revenues for Venture Capital through the introduction of tax incentives).

Lastly, granted that there is a great fluctuation in the allocation of R&D activities, and in the production of innovations per member-state and region in the European Union, the further promotion and development of regional assemblies [9, page 8] of research and innovation centres is considered useful. The most successful examples of co-operation between the industry and the academic society include liasons with universities and local industry clusters. These collaborations guarantee a frequent flow of information and communication from both sides and support the financial economic on a local level.

The role of companies

A significant number of SMEs are characterised by a particularly weak R&D potential. A portion of those companies appears not to have an adequate base of knowledge and resources in order for it to interact effectively with universities and research organisations. It has been proved that intermediary organisations, [9, page 24] including the consultants, can fill in the above gap by encouraging the companies to maximise the benefit from knowledge coming from universities and to effectively incorporate the results of this knowledge in their business strategies.

It is a common belief that the research and production of innovations now concerns companies of all fields and sizes. Companies and industries, as entities on the side of demand, are obliged to adapt, participate in company networks - communities [9, page 24] - supply chains producing knowledge, new technologies and products.

The business sector for its part, is obliged to support the governments in their attempt to improve the climate of creativity and innovation [4, page 7] and to co-operate, via its organisations, in essential collaborations for the promotion of a partnership culture which is aware of the market's changing demands and contributes to the development of innovative activities.

On this basis, the businesses are now invited to promptly search for and take advantage of all contemporary opportunities to develop new procedures, products and services, by allocating more resources to research and development (increase of R&D expenses of the corresponding international levels) and upgrading their existing productive infrastructures [4, page 7]. At the same time, the businesses are obliged to acknowledge the leading part of technology today (through the achievement of results, it has been elevated to the position of the main strategic factor in the formation of company policy) and to merge their technological and business strategies.

Simultaneously, having adequate staffing as their main goal, it is necessary for the firms to establish long-term contracts and collaborations with universities and research centres. It is a fact that businessmen want the rapid transformation of research results to practical results; however, they are also obliged to acknowledge that most of the time, the research results from universities demand a considerable amount of time to develop into practical solutions/products/services and by extension, the benefits are not immediate. Firms can help scientists introduce ideas to the market, while, at the same time, they can benefit from their access to new ideas which are brought about in research laboratories and databases in universities, and to a wide range (both in terms of quality and quantity) of graduates with specialised skills [9, page 10].

Moreover and in order to make full use of the new knowledge, firms are obliged to have an adequate absorption capacity. The above need, combined with the necessary reformation of the organisational framework, renders the attraction and retention of human capital strategically important. Today, companies are obliged to supply more resources for the complete education and training of their existing personnel. Research and development is not only a generator of innovations, but also a producer of skills and qualifications. The usual practice of the leading companies in the world [9, page 27] which search for specialised employees throughout the world, is ongoing in-house promotion - upgrading of their executives, through the appropriate in-house training, regular job rotating, as well as the granting of high salaries and suitable working conditions. In the process of maximisation of investment resources and research products or services, the development of interdepartmental working groups is also considered to be the most effective best practice.

The role of universities and research institutes

In the process of creating effective synergies between universities or research institutes and the production agents in European countries there is today a considerable number of institutional barriers, which make the exploitation of state-funded innovations particularly difficult.

Universities and research institutes, as the main entities which supply knowledge and research and innovation infrastructure, must elaborate and develop the new issues raised by the industry concerning the training of scientists and technologists, in order to equip their graduates with the necessary qualifications for contemporary labour markets. Their main goal is to create and disseminate new knowledge more effectively in order to ensure an adequate amount of skill for the complete support of innovations and entrepreneurial activities.

In this attempt, the universities are obliged today, more than any other time, to gradually alter courses, their orientation, as well as the incentives given for research and collaboration with the business sector.

Today more than any other time, the universities are invited to co-operate with businesses and applied research and alter their culture and orientation. A closer co-operation with businesses entails new sources of funding for the universities, new areas for the development of research in specialised scientific fields, as well as real opportunities for the optimum absorption of their graduates in the labour market. Besides, it is a fact that the prestige and acknowledgement of contemporary universities comes not only from their traditional theoretical applications, but also from their standard in terms of their contribution to innovative research [9, page 9].

At the same time, the increasing demand of the new economy for employers with a wide range of knowledge and innovative thought, in order to negotiate issues affected by multiple thematic fields of science, compel universities to develop a variety of interdepartmental programmes.
Research institutes and in particular government research institutions (universities and government laboratories) and the industry are obliged to determine, in practice, how they will upgrade their co-operation. The ability of these institutions to develop services which truly contribute to the successful commercial transfer of knowledge, demands the effacement of the strict and bureaucratic rules and procedures. Also, the development of personnel mobility between government research institutions and the industry [2, page 32], as a practice of vital importance for the promotion of research and innovation, requires the development of new policies for employment and human resource management in order to deal with the existing problems.

Lastly, the improvement in co-ordination between the various research centres situated in Europe will restrict the duplication of effort, will allow the creation of larger and stronger infrastructures and will lead to the creation of integrated European research communities. [11, page 11]

Conclusion

The European Union's goal for the next decade, as it was expressed in the European Council in Lisbon [12, page 1], is to become a leading economy of knowledge under conditions of full-time employment and social cohesion. This prospect requires the alertness of all the entities of the research and innovation systems of the E.U. and at the same time, the development of synergies and the effacement of any contemporary lag in the existing institutional frameworks.

The creation of dynamic and innovative businesses and regional economies, as well as the further strengthening of the research potential, constitute a leading factor for the sustainable development and ongoing competitiveness of the European Union and constitutes a complex venture which imposes the strengthening of the ties between research and production. The combined and sustainable development through research activities and innovations leads to the strengthening of the economy and competitiveness of each country in an international environment which appears to be fully aware of the importance and benefits of research and innovation and constantly improves its performance in this field [7, page 1].

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3.2 New Directions, New Capacities – the Role of Foundations: the Specific Case of the European Science Foundation

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Foundations, drawing upon private and/or public funds, provide an important source of research support in European countries. Often foundations have had an innovating effect on research agenda and capacity-building by acting as vehicles through which researchers can explore new research ideas and directions. Foundations will occupy a significant, and independent, space within the forthcoming European Research Area as alternative sources of research funding. Competing sources for research funding are essential for the health of science and scientific disciplines. Foundations should continue to seek to be “one step ahead” through keeping their agenda open to new researcher-led initiatives that explore new directions and new capacities to address societal challenges.

The role of foundations will be illustrated by focussing on the work of the European Science Foundation (ESF). At the outset, two opening remarks need to be emphasised. Firstly, the European Science Foundation is a publicly-funded body (registered as an association under French law with its base in Strasbourg) with its “member associations” as national research funding bodies, mainly research councils (and their equivalents) and academies of sciences – 70 currently in 27 European countries. It is dependent largely on its financing via membership contributions from these public bodies and their “a la carte” funding of specific research programmes and other research activities that interest them. Its name as a foundation, therefore, is rather a misnomer because it is not in receipt of any endowment funds from a private benefactor. This makes its role and functions somewhat different to private foundations as such, and these differences will be addressed below. Secondly, the author should declare a certain bias through having worked at ESF as its Head of Unit for the Social Sciences for many years, and hence is content to be asked to address this workshop session which has as its overall theme, “success stories for capacity-building”. Having left ESF over two years’ ago, the approach taken and the illustrations used here tend to reflect the experience of those years (1987-2000), and not up-to-the-moment events. Nevertheless, an eye has been kept on recent developments and some observations are made on how ESF is defining its role within the emergent European Research Area debate.

As a starting-point, the scale and size of ESF and its activities should be borne in mind, and put into perspective with that of other foundations. The total annual operating budget falls within the range of 15-16 € million which covers all its scientific activities, staff and administrative costs. Over half of the annual budget has been raised normally by “a la carte” budget contributions to scientific programmes which are “non-compulsory”. The success of the ESF over the years, therefore, has been in identifying and developing scientific activities that are attractive enough to member organisations to make them invest “a la carte” in ESF beyond the level of their compulsory membership dues. In doing so, the ESF has performed a kind of “outreach function” for research councils, extending their European cooperation beyond traditional mechanisms such as bi-lateral agreements. The relative small beginnings of the ESF from 1974, in terms of its limited budget, also led it to experiment early with new mechanisms for research funding which maximised its resources. After establishing its membership base and organisational structure, from the early 1980s it began to experiment with a modest scientific network scheme and to develop the European Research Conferences (as a European counterpart to the US Gordon Conferences) in the late 1980s, both of these mechanisms were subsequently taken further in the context of the European Commission Third Research Framework Programme. In the early 1990s exploratory workshop schemes were launched on a competitive basis to provide “seed money” particularly to young researchers to establish and consolidate professional contacts on the European level for networking and project development purposes. These new mechanisms both combined with and strengthened “a la carte” scientific programmes through the input of new ideas and new research collaborations.

Research capacity building initiatives at ESF can be most usefully examined through the operation of four conceptual approaches of “Flexibility”, “Interdisciplinarity”, “Risk-taking” and “Think tank” function. Working examples are drawn below from ESF activities in the social sciences (reflecting the author’s area of responsibility while at ESF). As a relatively small organisation, the ESF’s flexibility in terms of freedom to manoeuvre in exploring and identifying new fields for research enquiry has been a great asset. Topic choice for new scientific programme development has not been so constrained by lengthy negotiation and conciliation processes that are necessary at national government councils and ministry levels when “targeted” research areas are developed. Although programmes are developed initially in ESF Standing Committees in the different fields of science (Humanities; Life and Environmental Sciences; Medical Sciences; Physical and Engineering Sciences; and Social Sciences) where chief executives and/or current members of research councils are present, the selection of topic fields is undertaken in a collective manner not simply on a “country interest” or “representative” basis. Such a flexible approach to topic choice and decision-making owes a great deal to the skilfulness of Committee chairmen/women who are selected by “search committees” and appointed by the ESF Assembly as a whole. The Chairman serves in an independent capacity normally for a four-to-five year term which also helps to provide a considerable degree of continuity in committee policy. In the social sciences, the Standing Committee policy development has benefited greatly by being steered by the hands of leading scientists such as Helga Nowotny, Guido Martinotti and Robert Erikson.

Innovative choices have been made on new programmes which sought to tackle “up-stream” topics with comparative approaches and methodologies. Social Science programmes were developed in fields such as “Regional and Urban Restructuring in Europe (RURE)” which brought together regional scientists, geographers and planners, economists and sociologists in early research collaborations on European economic integration and development. “Beliefs in Government” drew upon data bases from several sources to conduct an extensive comparative secondary analysis of European public attitudes and social and political values, and the “Environment, Science and Society” programme (and its successor, “Tackling Environmental Resource Management, TERM”) established a lasting network of collaboration in socio-economic and behavioural research on the environment which was followed through with the establishment of professional associations and projects funded under the EU Fourth Framework programme on Human Dimensions of Environmental Change. The “Transport and Communications” programme (later known as the Network for European Communications and Transport Activities Research, NECTAR) brought social science disciplinary perspectives into a research field dominated by engineering and logistics approaches. Such programmes were essentially networks of capacity-building which were sustainable because they were supported over a reasonable period of time. Their duration was between 4-5 years and a core of between 50-80 researchers were involved in linked workshop series, joint sessions and conferences organised on a self-management basis.

The above-mentioned scientific programmes demonstrate also that “interdisciplinarity” exists as a central conceptual approach in developing ESF social science initiatives. Interdisciplinarity is seen to be important in two respects, both within the social sciences, and between the social sciences and the natural and medical sciences. The importance and need for interdisciplinarity within the social sciences has been too often understated. Interdisciplinarity is an incremental process and before socio-economic research dimensions can be integrated effectively into natural and medical sciences fields, a great deal of bridge-building across social science disciplines, sharing of perspectives and methodologies, needs to be achieved so that the right “mix” of social science disciplinary approaches can be brought to bear in particular sectoral topic fields such as environment, health and transport. The “Environment, Science and Society” and “TERM” programmes were pioneering in this respect of bringing together the then quite disparate and few researchers beginning to define the field of socio-economic environmental research as an interdisciplinary field on the European level. This approach of identifying and supporting interdisciplinary capacity-building efforts within the research communities has been continued through other programmes such as “Social Variations in Health Expectancy in Europe” which combines medical and social science research approaches to life-course analysis, focussing on home life, work environment and lifestyle factors.

“Risk-taking” as a conceptual approach links with fostering interdisciplinary research collaboration. For example, a major initiative taken by ESF/SCSS was the launching of an interdisciplinary “a la carte” programme on “Geographic Information Systems: Data Integration and Data Base Design” (GISDATA). The programme aimed to promulgate the potential of GIS technology and methodological applications in the social sciences. GIS technology offered the scope for handling and combining layer upon layer of data to examine socio-economic developments, e.g. a working group from GISDATA used satellite remote sensing data on urban development, combining it with census data and other administrative data on households to provide a multi-dimensional socio-economic analysis of urban landscapes, district by district. The programme established an interdisciplinary network of researchers that has continued as a professional research association and led to a series of publications demonstrating GIS methodology applications in particular subject domains. Investment was made in young researchers particularly as programme coordinators who provided enthusiastic and competent leadership. To the author’s knowledge, young researchers who have coordinated ESF programmes, and have established new networks of professional colleagues and contacts throughout Europe, have been able to capitalise successfully on these collaborations in their subsequent careers. Only a few scientific entrepreneurs are necessary to start to move forward a new field of enquiry.

An element of “Risk-taking” is also necessary and worthwhile in introducing new funding mechanisms. The introduction of “ESF exploratory workshop schemes” from the early 1990s onwards was designed particularly to give young researchers “start-up” capacity for professional network building on the European level. Many researchers who received funding under such exploratory workshop activities proved later to be successful partners in EU projects in the Targeted Socio-Economic Research Programme of the 4FP and the 5FP programmes and key actions.

The ESF “Think-Tank” function has been employed across many fields from best research practice studies to addressing questions of ethics in research but, perhaps most prominently, in providing scientific advice and input to research policy priorities in EU Research Framework Programmes. In the social sciences, this “think-tank” function began to be developed from 1991 onwards with the publication of “Social Sciences in the Context of the European Communities” (Howard Newby et al) jointly undertaken for EU/DGXII (Research Directorate) by the ESF and the Economic and Social Research Council (UK). This was followed by other advisory reports to EU on social science priorities for the 4FP (G. Martinotti et al, 1994) and 5FP (R. Erikson et al, 1997) and expert hearings organised for the European Parliament’s Committee for Energy, Research and Technology in 1993 and 1997.

In recent years, the ESF has focussed its attention on medium to long- term needs for effective research input to European policy options development, and in the social sciences (as in other sciences) a key concern has been with research infrastructure investment. The argument has been made that that the social sciences need European infrastructure investment too – not in central research institutions (such as a social science CERN) – but in research instruments and data such as comparative surveys and distributed networks of data holdings for secondary analyses. From 1995, ESF established an expert group to make the case for an academically-driven European Social Survey which was subsequently approved, and a “scientific blueprint” for such a survey was then developed as an “a la carte” programme with financial contributions from over 20 countries. The scientific blueprint has been transformed successfully into an operational European project through funding under both the EU/5FP and national funding agencies. The EU financing covers the central costs of the development of the European Social Survey questionnaire, methodology and quality control, while national funding covers survey fieldwork costs and local coordination. At time of writing, the first wave of the European Social Survey is currently in the field. This innovative project is not, of course, without its risks, operational challenges and problems but it is a pioneering venture in two key respects, as a new European social science infrastructure facility and as an effort to bring about coordination and linkage between EU and national research investment.

On this latter point of coordination between European and national research funding, ESF can claim to have considerable experience. It has often described its “a la carte” programmes as “tips of the iceberg” providing a visible layer of European level activities with quite modest funds (an average “a la carte” programme has an annual budget of 250-300,000 Euro), but they span and engage researchers from national research institutions and programmes commanding much larger budgets. In this respect, ESF has a valid ambition to play its full part in the implementation of Part III of the 6FP on “Strengthening the Foundations of the European Research Area”. Whether these ambitions can be more broadly expanded later into providing the framework for a European Research Council is a subject of current debate. For this to occur, national funding bodies would have to formulate a clear vision of what they want such a body to achieve, and what level of resources they would wish to “earmark” to its activities. In many ways, the ESF has been an under-utilised asset by its member organisations whose true potential has not been realised. For its part, ESF has to resolve its inner dilemma of seeking to be both an “independent voice” for scientists to influence scientific agenda and priority- setting, and as “an organisation of organisations” seeking to negotiate and articulate collective views on behalf of its member organisations vis-à-vis European science policy and programme innovation/development.

As stated at the beginning of this presentation, these above aspects render ESF quite different from privately-funded foundations. But, in recent years, private foundations such as the Volkswagen Stiftung have focussed more attention in developing thematic priority programmes in addition to an “open topic” approach. Also, private foundations have become more engaged in science policy debates, such as the “Re-Thinking Science” initiatives of the Gulbenkian Foundation. So, it can be argued perhaps that private foundations are moving closer to national funding bodies in terms of goals and objectives. The future climate may be ripe, therefore, for public/private innovations in building new research funding institutions. To keep within the context of the social sciences, which have served as a working model throughout this paper, a new European research funding institution adapted from the model of the US Social Science Research Council (based in New York) might be a starting point for consideration of new public/private joint ventures. The US/SSRC receives support from both the National Science Foundation and major US private foundations and represents an alternative, competitive funding source for social science research. In the current situation where the EU/6FP devotes only 1.5% approx. of its budget to socio-economic research, an innovative funding institution in Europe to further stimulate new directions and new capacities in social science research would seem to be a high priority.

Chapter 4: Key components in capacity building: human and physical capital

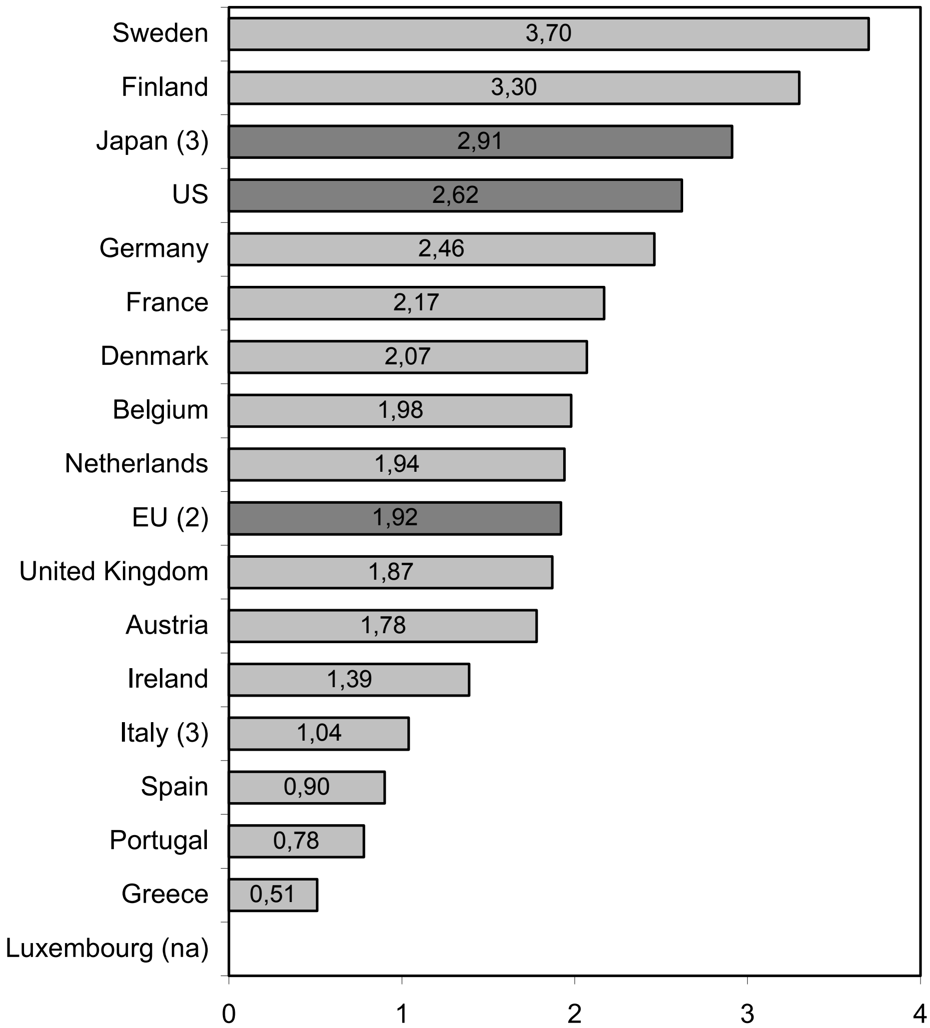
4.1 Researchers in Europe: A Scarce Resource?

Thora Margareta Bertilsson, University of Copenhagen, Denmark

Looking at recent statistics on R&D investment in Europe, USA and Japan, there have been concerns that Europe is lagging behind its main competitors unless such investments are efficiently increased.

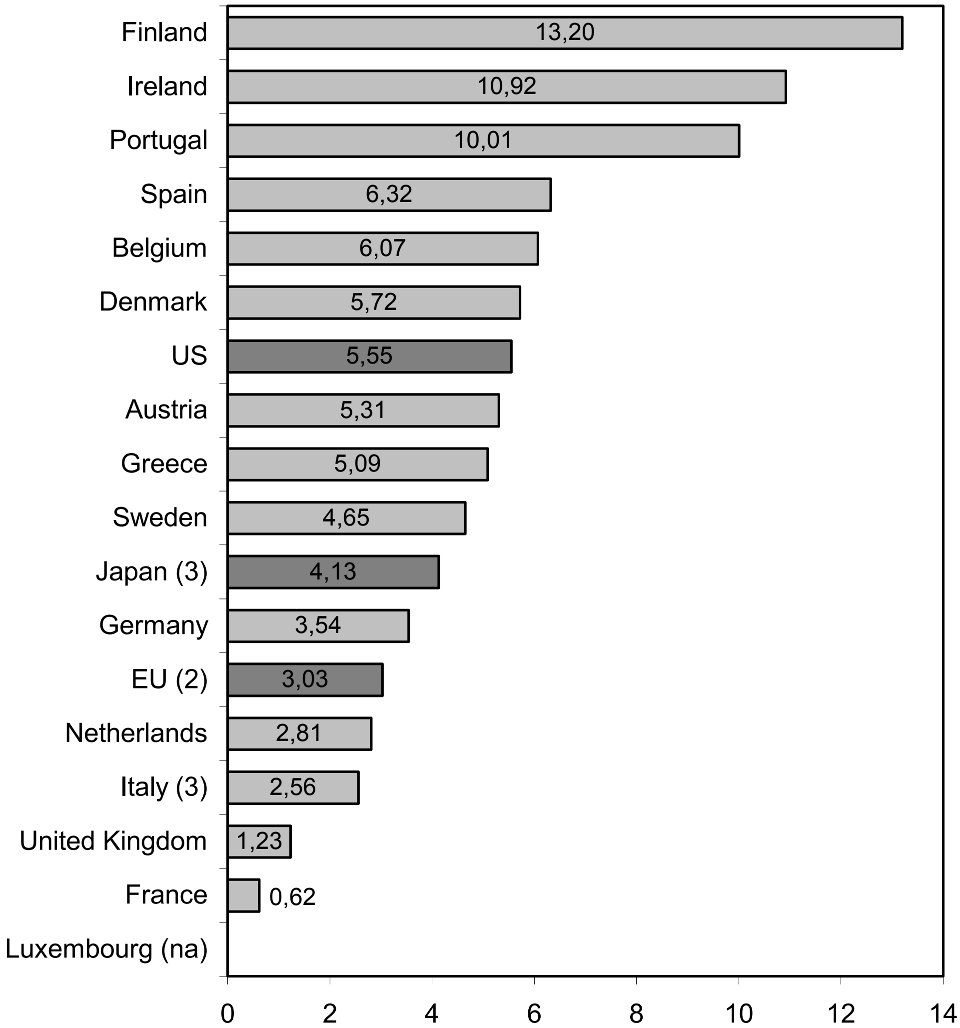
Table 1a, 1b: Investments in Research and Development

Table 1a. R&D intensity (%), latest available year (1)



Source: DG Research.
Data: Eurostat, Member States, OECD, Japan (Nistep).
Notes: (1) D, A, P, FIN: 2000; NL, JP: 1998; EL, IRL, S: 1997; all other countries and EU: 1999. (2) L data are not included in the EU average. (3) See annex.

Table 1b. R&D expenditure - average annual growth (%), 1995 to latest available year (1)

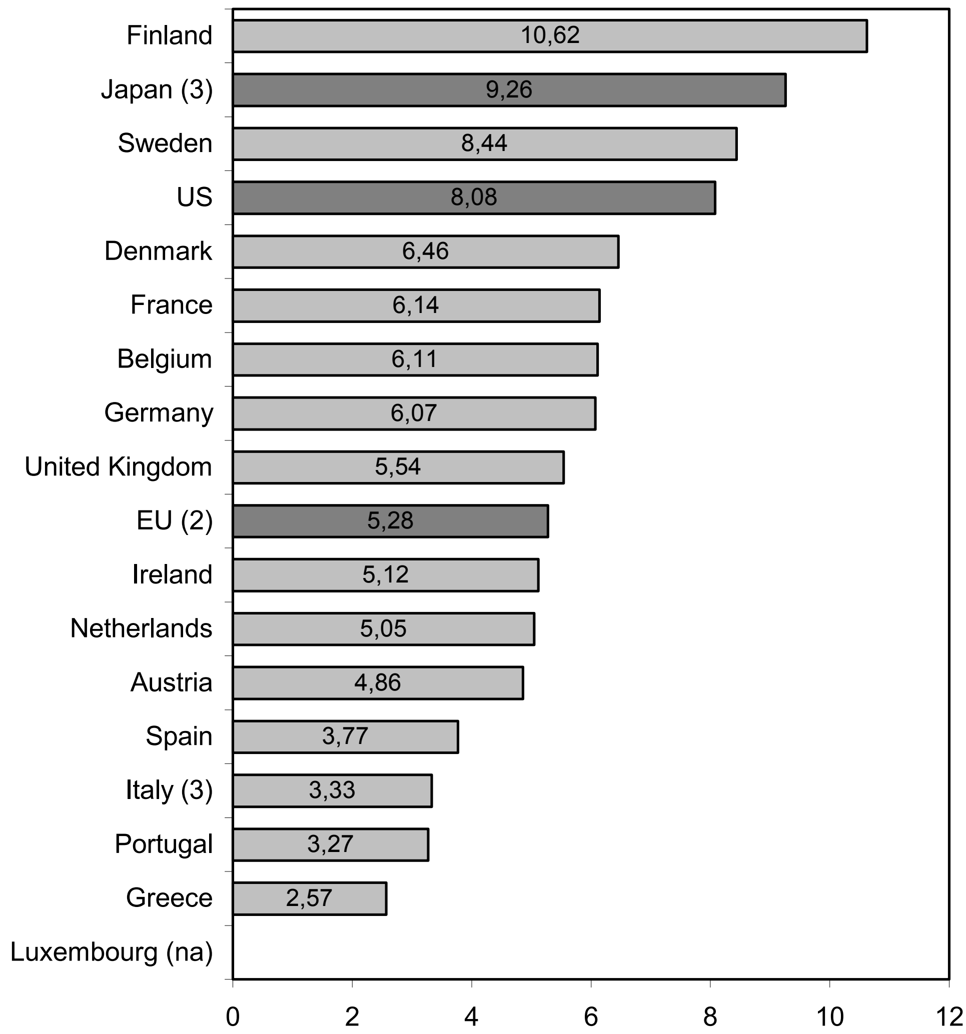


Source: DG Research.
Data: Eurostat, Member States, OECD, Japan (Nistep).
Notes: (1) D, A, P, FIN: 1995-2000; NL, JP: 1995-1998; EL, IRL, S: 1995-1997; all other countries and EU: 1995-1999. (2) L data are not included in the EU average. (3) See annex.

Such R&D investments also demand a considerable amount of “knowledge workers”. Hence, a strong focus is now directed at the efficiency of European higher education to increase its production and quality of PhD students.

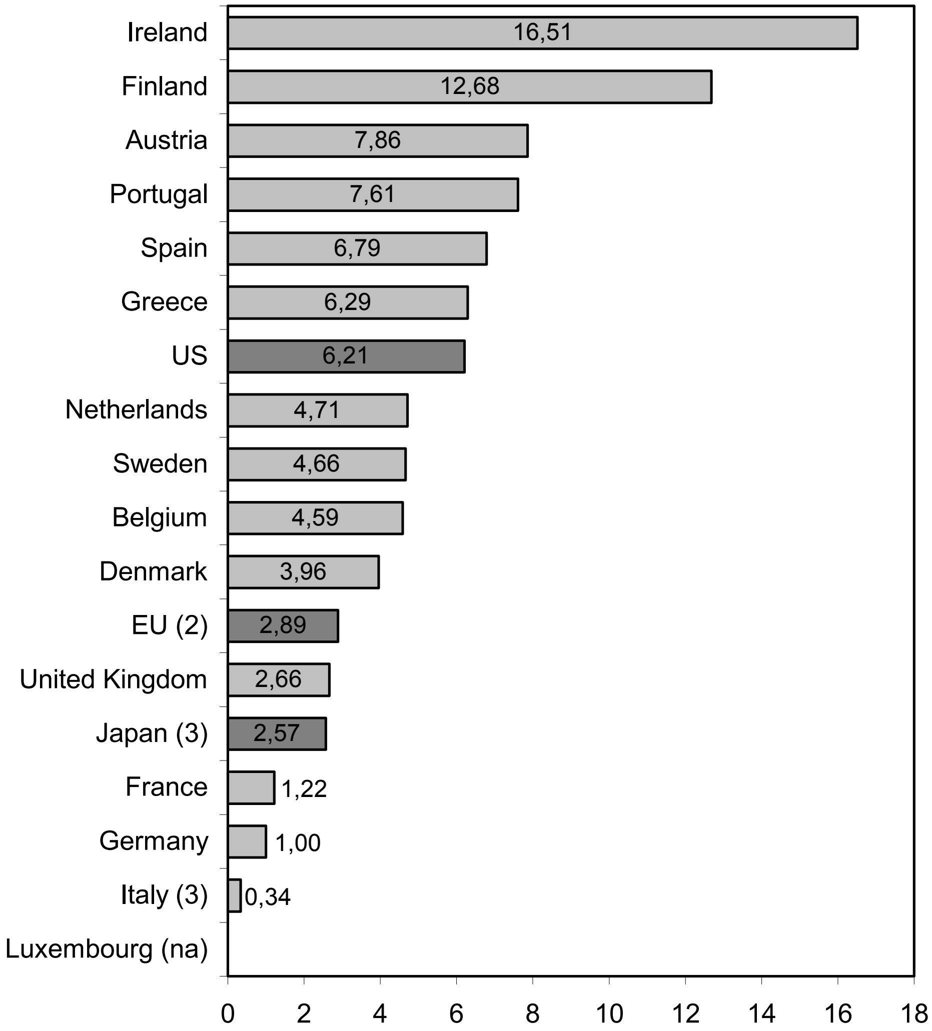
Table 2a, 2b: Number of Researchers in relation to population (per thousand)

Tabel 2a. Total researchers (FTE) per 000 workforce, latest available year (1)



Source: DG Research.
Data: Eurostat, Member States, OECD, USA (NSF), Japan (Nistep).
Notes: (1) P, JP: 2000; D, E: 1998; B, EL, IRL, I, FIN, S, US: 1997; all other countries and EU: 1998. (2) L data are not included in the EU average. (3) See annex.

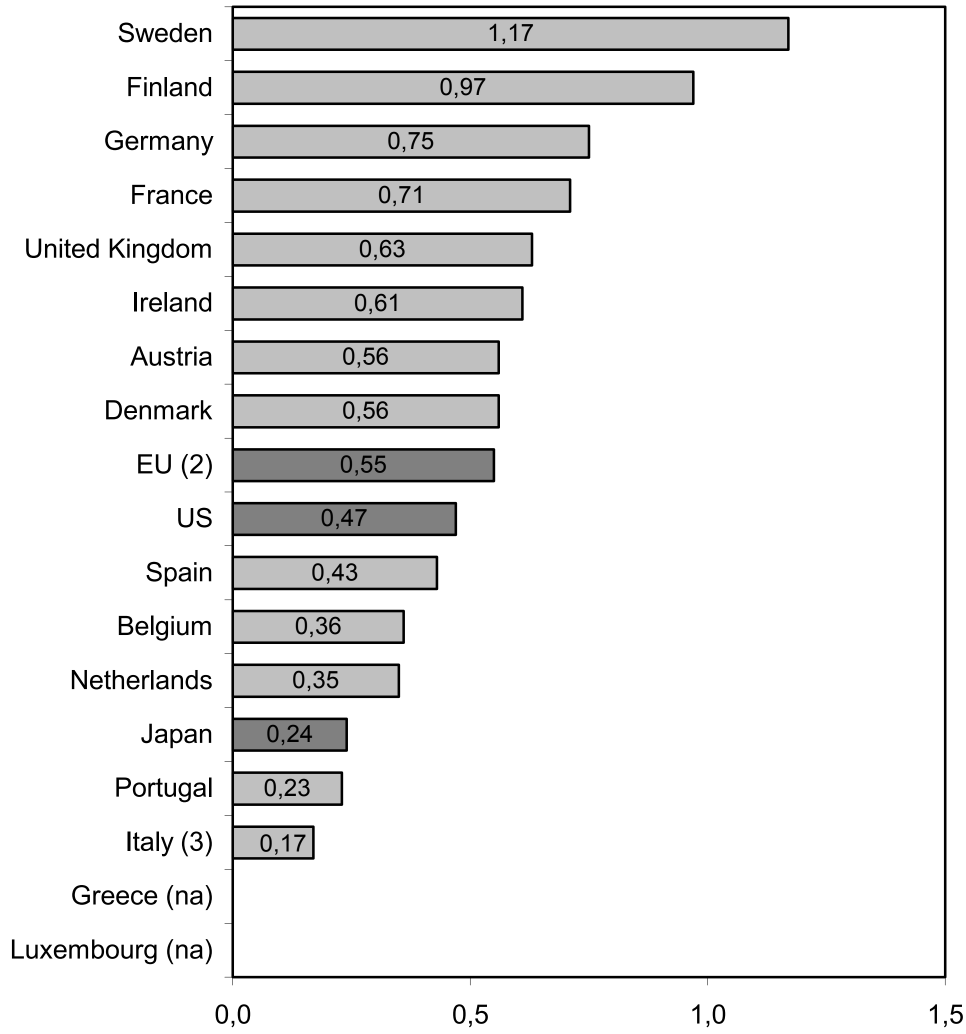
Tabel 2b. Total researchers (FTE) - average annual growth (%), 1995 to latest available year (1)



Source: DG Research.
Data: Eurostat, Member States, OECD, Japan (Nistep).
Notes: (1) P, JP: 1995-2000; D, E: 1995-1999; B, EL, IRL, I , FIN, S, US: 1995-1997; all other countries and EU: 1993-1998. (2) L data are not included in the EU average. (3) See annex.

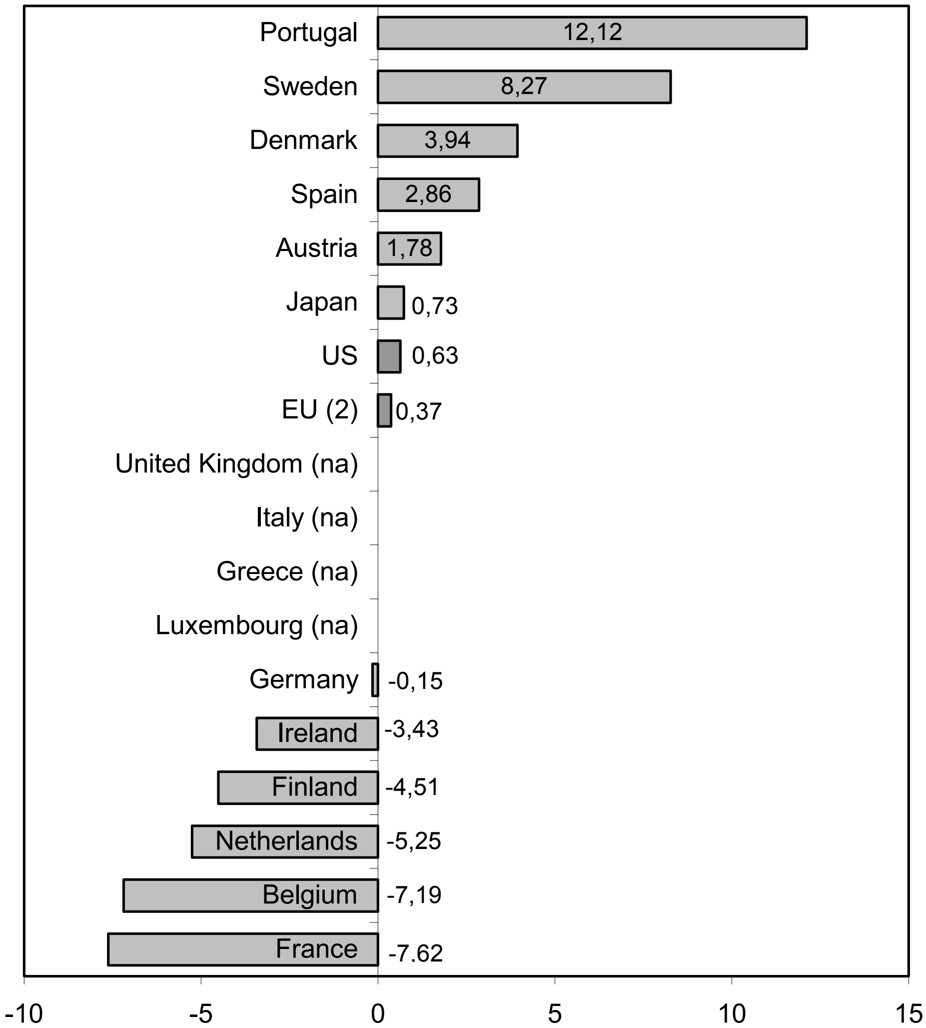
Table 3a, 3b: PhD students in relation to age cohort

Table 3a. Total new Science and Technology PhDs per 000 population aged 25 to 34 years, latest available year (1)



Source: DG Research.
Data: Eurostat, Member States, OECD, Japan (Nistep).
Notes: (1) F, E, UK, EU: 1998; I: 1997; all other countries: 1999. (2) EL, L data are not included in the EU average. (3) See annex.

Table 3b. New science and technology PhDs growth (%), 1998-1999 (1)



Source: DG Research.
Data: Eurostat, Member States, OECD, Unesco, Japan (Nistep).
Notes: (1) F, E: 1997-1998; all other countries and EU: 1998-1999. (2) EL, I, IRL, L, UK data are not included in the EU average.

As is clear from recent statistics and also discussed by Karen Siune in her presentation to this workshop, European figures concerning R&D developments are pointing in many diverse directions. Siune maps the figures in accordance with regions, Nordic, Continental-European, and Southern European, and find – as is clear to anyone looking at the figures – that the Nordic performance, and especially the success story of Finland, is most remarkable. Siune also notes that there are several other countries, Ireland and Portugal are good examples, which now show a staggering growth rate in R&D personnel.

What is of further concern in these figures is the slow growth rate of R&D personnel in some central European countries such as Germany, France, and especially Italy. However, average growth rate must be read with great caution, as countries start from very different level.

What I would like to look closer at in this presentation is the quite outstanding performance of the Nordic countries in the R&D statistics, and especially the case of Finland. But my presentation is not about praising Nordic exceptionalism, but will be an attempt to trace an explanatory framework behind such strong performance. In such a way, I hope to be able to isolate certain sets of factors and regard these from within a wider framework: are these factors specifically Nordic or can they be applied much wider. From such a point of view it is also possible to ask whether or not the presence or absence of these factors can help to throw light on the scientific performance or its slow growth in other European countries as well. Furthermore, by applying a set of explanatory hypotheses it is also possible to respond more sharply to the problematic questions of European R&D performance in general: Can a United Europe, following in the leads of the Nordic countries, exploit its knowledge potential better than it seemingly does and compete with and perhaps even outperform US in the long run?

Explaining scientific productivity

In the history of science, scientific success has shifted between countries and continents over time. In the 16th century, Italy was the centre of science – which can be contrasted with the poor position that Italy holds today. Hence, there is nothing constant in scientific success performance: it shifts considerably over time. England was the most advanced scientific nation in the second half of the 17th century, France around 1800, Germany around 1840, and United States has clearly taken the lead in the 20th century. In that wider historical perspective it is of interest to note the exceptional performance of the Nordic countries today: Finland now outperforms Unites States on several R&D criteria. The question has even been raised if United States is loosing its pre-eminence in the republic of science. (Cole and Phelan 1999: 1)

The explanation of scientific productivity has long been a central concern of the history and the sociology of science. I will attempt to draw upon some basic theories from these specialties in order to better understand the variance between the European countries regarding their R&D performance. In such a way it is possible to critically test the classic theories and see if they are still viable as explanatory framework in accounting for more recent high tech environment, or if these theories are in need of reformulation in the light of present development.

Special or general theories of scientific progress

Should the success rate of Finland, such as we see it in the last decade, be explained by specific or generalisable factors? The same question is applicable in the case of Ireland showing a staggering R&D growth in the last couple of years – or for that matter the case of Portugal. In each of these instances, some specific, historical, factors seem to be present which can hardly be transferred to other nations. When the Soviet Union collapsed in the late 80s, Finland lost its most important market, and suffered a considerable recession in the early 90s. Heavy investments in new markets, in R&D investments, and a very strong turn to Europe (in contrast to the other Nordic states) characterise modern Finland. Doctoral degrees have tripled since 1990: from 490 to 1 203 in 2001 (STRATA-ETAN: 105).

Table 3c: Growth rate of Finnish PhD production

Year	Total, university students	Total, postgraduate student	Total, Master's degree	Total, Doctotal degree	Master's degree, females (%)	Doctoral degree, females (%)
1990	110.700	13.363	8.423	490	54,1	31,6
1991	115.573	11.839	8.410	524	54,7	32,6
1992	122.200	13.359	8.713	527	55,0	30,6
1993	123.100	14.218	9.439	647	55,1	36,6
1994	128.267	14.730	9.615	698	56,4	36,2
1995	135.107	15.927	9.819	765	56,0	37,1
1996	138.173	16.674	10.611	851	57,5	40,2
1997	142.818	18.056	10.893	934	57,2	40,1
1998	147.263	18.958	11.343	988	57,5	39,7
1999	151.900	19.842	11.856	1.165	56,1	43,3
2000	157.195	20.537	11.515	1.156	58,3	45,2
2001	162.785	21.008	11.581	1.203	58,0	44,5

Finnish degree production for the period 1990-2001.
Source: STRATA-ETAN Expert working group, *Human Resources in RTD* (including attractiveness of S&T professions) 8 May, 2002, p 105.

Finland's R&D expenditure as a fraction of GDP is among the highest of all OECD-countries. It has been growing steadily, particularly in the latter part of the 1990s. The main share of this rapid growth is coming from private business, in this case from the electronic industry, more specifically from NOKIA. Again, is the Finnish case so exceptional that it is not possible to learn any general lessons from here?

The STRATA-ETAN (2002) concludes with summarising the special factors that have been in operation in the case of Finland in the last decade: amongst these are political consensus, well-functioning system of decision-making and planning, high level information technology infrastructure, active research cooperation in the country and with EU, large investments in education and full regional coverage by the university system, highly educated young people and motivated students on all educational levels, a wide-range of high quality education in engineering, well qualified teachers, a strong focus on the quality of scientific research, profitability of R&D investments (in terms of patents), close co-operation between many different actors, active internationalisation.

Some of these factors are certainly specific to Finland such as a highly centralised political and educational system. However, as we will see later, the high investment in the organisational structure of the higher education system and increased opportunities both to students and to young researchers are certainly factors which have much more general significance: in fact, these organisational factors are, according to some classic theories, highly determinable of scientific success in more general terms.

Some of the same questions can be asked in the case of modern Ireland. However, in contrast to Finland, it is a question if the Irish case depends more upon foreign "market invasion" than on domestic long term investment in R&D?

Table 4: Investment in Education

	Total expenditure for all types of institutions Mio PPS	Total number of pupils students enrolled 4) 000s	Total direct public expenditure for all types of institutions Mio PPS	Total direct public expenditure per pupil or student Mio PPS	Total public expenditure in tertiary education Mio PPS	Total number of students enrolled in tertiary education 000s	Total public expenditure in tertiary education per student PPS
B	6.876 1	2.589	6.343 1	2.450 1	1.420	361	3.935
DK	8.354 2	1.176	8.000	6.802	2.197	180	12.183
D	96.314	16.784	76.351	4.549	19.185	2.132	8.999
EL	6.191	1.966	4.329	2.202	1.072	363	2.951
E	32.827	9.356	27.195	2.907	5.709	1.684	3.389
F	71.735	14.582	65.787	4.512	12.268	2.063	5.948
IRL	3.555	1.002	3.169	3.162	970	135	7.209
I	52.943	10.883	50.199	4.613	8.116	1.893	4.289
L	565	70	565	8.050	22	3	8.456
NL	16.040	3.510	14.098	4.017	4.739	469	10.106
A	11.512	1.641	10.660	6.496	2.917	241	12.121
P	7.936	2.312	7.905	3.419	1.461	351	4.165
FIN	6.143	1.192	6.143	5.154	2.000	226	8.830
S	11.676	2.159	11.333	5.249	3.632	275	13.196
UK	52.000 3	14.224	50.181	3.528	12.564	1.897	6.643
EU-15	384.665 3	83.448	342.258 3	4.101 3	78.273 3	12.267	6.381 3

Source: Research DG.
Notes: 1) Flemish Community only 2) 1996 data 3) Estimated by Research DG 4) ISCED 0-7

Whereas Finland has invested heavily in educational institutions by means of public funding, Ireland stays in this regard on a European average. However, the private investments outperform all the other European countries in 1997 with Spain as a close follower. Not having enough of knowledge of the local case, it is difficult to know whether or not the private investments in Irish higher education are of long term or short term character.

In contrast to the peak figures of Finland, Ireland has a modest, albeit average European, share of its student population interested in science and technology. In perspective, it seems to be problematic for Ireland to maintain its staggering growth of knowledge workers – unless these on a mass scale are to be imported from the outside!

Most certainly, some special considerations also apply to the rapid Portuguese growth rate but I am not in possession of knowledge of the local case.

The point here is rather to stress that in any case of scientific success we will have to consider some special factors of a unique character. However, special factors do not rule out the possibility that the chain of explanation also can harbour more general ingredients as “necessary” in explaining success rate in performance. It is to these more necessary and therefore general theories that I now will turn. But I want to stress that in no case can these necessary factors account for the whole chain: any case needs to be supplemented by special factors.

General theories of scientific success

Although there are many different theories accounting for scientific success performances, social scientists seem to agree on at least this one factor:

> "advance was dependent upon the number of talented individuals who select science as a career." (Cole and Phelan: 2).

Certainly, there have been a number of scientific geniuses in the course of history, but such geniuses also are in need of milieus where their genius can thrive and where their achievements can be duly acknowledged. But the question is: what are the factors that seemingly influence and possibly increase the pool of scientific talents? In more mundane language, we may ask: how are creative and productive scientific milieus created?

In the history and sociology of science, there are at least three different types of theories: cultural, organisational, and wealth-oriented.

Cultural theories

One classic theory in the sociology and history of science is the *cultural theory* that Robert Merton advanced already in the 1930s (Merton 1938/1970). His study of 17th century English science showed that after the Reformation in England, the rate of scientists increased considerably. Implicit in Merton's theory was the hypothesis that Protestant societies place a higher value on scientific – laboratory – activity, and hence, these societies will profit from greater scientific activity. Implicit in the theory is also a belief in a linear proportional relationship between the number of scientists and the amount of valuable science produced (Cole and Phelan: 2).

Before applying this handy theory to the variation in European R&D statistics, and proclaim the sovereignty of Protestantism in accounting for scientific success, we need to consider some complicating factors. The Nordic countries have been Protestant for centuries, but it is seemingly first in the latter half of the 20th century that these countries, as in the case of Finland, enter as serious competitors on the international science scene. And a clearly negating case of Merton's thesis for that matter is the case of contemporary Germany.

Table 5: Regional performance

R&D expenditure/GDP 1997			R&D personnel (head count) /labour force 1997			Employment in high-tech industries in the manufacturing sector/total employment 1998		
	EU-15=100	%		EU-15=100	%		EU-15=100	%
1 Oberbayern (D) [4]	248	4.7	1 Stockholm (S)	290	3.6	1 Stuttgart (D)	265	20.4
2 Braunschweig (D) [4]	239	4.6	2 Uusimaa (FIN)	285	3.6	2 Tübingen (D)	236	18.2
3 Stuttgart (D) [4]	235	4.5	3 Oberbayern (D) [4]	271	3.4	3 Braunschweig (D)	224	17.3
4 Uusimaa (FIN) [5]	218	4.1	4 Braunschweig (D) [4]	252	3.2	4 Karlsruhe (D)	222	17.1
5 Pohjois-Suomi (FIN) [5]	213	4.0	5 Wien (A) [3]	231	2.9	5 Rheinhessen-Pfalz (D)	207	15.9
6 Tübingen (D) [4]	209	4.0	6 Île de France (F)	226	2.8	6 Franche-Comté (F)	202	15.6
7 Köln (D) [4]	190	3.6	7 Östra Mellansverige (S)	214	2.7	7 Mittelfranken (D)	201	15.5
8 Midi-Pyrénées (F)	187	3.6	8 Stuttgart (D) [4]	210	2.7	8 Freiburg (D)	197	15.2
9 Berlin (D) [4]	177	3.4	9 Västsverige (S)	204	2.6	9 Unterfranken (D)	195	15.1
10 Karlsruhe (D) [4]	175	3.3	10 Övre Norrland (S)	200	2.5	10 Darmstadt (D)	187	14.4
11 Île de France (F)	173	3.3	11 Karlsruhe (D) [4]	194	2.5	11 Piemonte (I)	182	14.0
12 Rheinhessen-Pfalz (D) [4]	159	3.0	12 Köln (D) [4]	190	2.4	12 Schwaben (D)	181	13.9
13 Bremen (D) [4]	149	2.8	13 Tübingen (D) [4]	185	2.3	13 West Midlands (UK)	174	13.4
14 Etelä-Suomi (FIN) [5]	144	2.7	14 Pohjois-Suomi (FIN)	179	2.3	14 Alsace (F)	171	13.2
15 Wien (A) [3]	137	2.6	15 Darmstadt (D) [4]	171	2.2	15 Niederbayern (D)	166	12.8
EU-15 [1]	100	1.93	EU-15 [1]	100	1.26	EU-15	100	7.7

Source: Eurostat, Data: Eurostat.
Notes: 1) Not including B, L, NL, S and UK, 2) Not including B, L, NL and UK, 3) 1993, 4) 1995, 5) 1998.

As stated in the Eurostat note: “There are considerable regional disparities in terms of R&D within the European Union. The leading regions for R&D activities are found in Germany with the next most important ones being in Scandinavia and France. These regions invest two or three times more in R&D than the European average” (note, p 71).

This observation of regional difference in contemporary Europe is of considerable sociological interest in the extent to which it qualifies Merton’s theory. It is Bavaria rather than northern (protestant) Germany that is taking a lead in R&D performance. Scandinavia and Ile de France hardly share the same religious values.

It may be further suggested that, as a global communication culture, modern R&D performance no longer is linked to a religious, domestic, context. Merton’s theory has historical value, but is probably “outperformed” by modern scientific culture. Merton’s theory is for that matter modelled on Max Weber’s study of the affinity between Protestant Ethic and Capitalism – but modern capitalism is as little as modern science linked to religious values: science and capitalism thrive in Japan as in United States.

However, even if it is no longer Protestantism and related values that are significant in explaining scientific success, we need to be highly cautious as to other “motivational” factors that may operate in the case of young talents choosing a science career. As of yet, it seems highly problematic to isolate a set of inner values of an idealistic type that lead young people to choose science rather than another career. But it is highly possible that some external, material stimuli are in operation: good research facilities, good salaries, good career opportunities etc. But such a (materialistic) motivation structure is linked to some other kind of theories.

Organisational theories

One of the most reputable sociologists of science, Joseph Ben-David, advanced a theory of scientific success linked to structural-organisational factors prior to motivational-cultural ones (1960). In order to increase the pool of talented scientists, the crucial mechanism is educational reform. When more universities are created in a country, competition between these university centres increases, and talented youth are at the same time offered richer opportunities. Hence, the pool of talents expands and intensifies; a motivational structure of high performance is the result. This was also how Ben-David explained the lead of United States from the 1920s and forward: the lead is mainly due to the superiority of the American higher education system in contrast to a highly centralised higher education system in traditional Europe.

Ben-David's theory seems easily applicable in the case of modern Finland and for that matter to the Nordic higher education system in general. Finland and Sweden are in the lead when it comes to PhD production in relation to the population at large. Both countries have reformed the higher education system profoundly: Sweden started already in the late 1960s whereas as we already have seen the Finnish system has gone through profound changes in the 1990s.

Clearly, the statistics on PhD degree production reflect educational reforms in various nations: Countries which have reformed the traditional system of graduate education in an American direction produce more PhD degrees. We need be cautious of the fact that non-PhDs researchers, as is often the case in for instance Southern Europe, are falling outside of present statistics.

The poor performance of Italy is particularly noticeable from this chart. Whether or not such a poor performance is due to the fact that the PhD system is not introduced in the case of Italy cannot be overlooked. However, it seems to be a strong developmental tendency in the higher education system to reform the graduate system as a requirement of industry in the presence of more advanced science and technology.

The good performance of Finland and Sweden with regard to production of doctoral degrees is most likely an effect of a highly de-centralised higher education system with full regional coverage. Such a decentralised system also demands that the pool of talented youth be expanded to include also that of women. Furthermore, it has been official welfare politics all since WW2 to democratise the higher education system so that traditional social class selection in the recruitment process, if possibly, be broken. But as more recent figures show, and despite official Social-Democratic policy, the aim to break social class selection in this regard is by no means completed (Hansen 1995).

A general support system offered by the state to enable talented students to continue in higher education has been strongly favoured by all Nordic Social Democrat Governments for several decades. Presently, Denmark has the most generous student support system of all European countries. The strategy to offer students a general financial support in the pursuit of a higher education degree has not only been a strong political value among Social Democrats, but has been supported in a much wider political setting as a necessary economic investment: an expanding industry and public service sector are in need of qualified knowledge workers – and the looking for a "reserve pool" of such talents, either in social class terms or in gender-terms, is serving strong economic-material need as well (Bertilsson 1999).

GNP and scientific progress

In the seminal book, *Little Science, Big Science and Beyond* (1963) Derek J. de Solla Price strongly stated that national scientific productivity measured as the share of the world's scientific literature is determined by its gross national product (GNP).

”Large wealthy countries produce the bulk of the world’s science.”
(Cole and Phelan: 3).

The wealth of a country determines how many scientists there are, and, hence, also the rate of advance. But Price’s theory of advance differs from most others in that it does not imply that there is a linear proportion between the number of scientists and the subsequent rate of advance. The numbers of scientists are growing exponentially and, as Price argues, this will probably mean that such countries sooner or later will run out of the pool of talents. The shortage of scientists will eventually cause a gradual decline in the average ability of those entering science (Cole and Phelan: 3).

As a following up of Price’s hypothesis on the diminishing rate of advance in science, the socalled *Ortega Hypothesis* was proposed (Cole and Phelan: 3). This hypothesis suggests that it may be possible to reduce the number of scientists while at the same time belonging to the top. The suggestion rests on the assumption that the “very best and brightest” can be recruited at any time. For obvious reason, this assumption, whenever applied, is bound to remain highly contested!

If we look at recent R&D figures with the aim in mind to test Price’s hypothesis on “diminishing value” of investment in human capital, the following reflections suggest themselves:

The US economy by far superseded the European Union and also Japan during the 1990s. However, some of the European countries have a long-term GDP in the 90s comparable, and in some cases, even outperforming that of United States (4.1%). Finland is again in a top position (4.7% between 95 – 99, while suffering from a negative growth, - 0, 5%, between 90 – 95). Ireland is in the absolute top with a GNP growth rate of 8.9 %. Luxembourg also has a top position of 5.6%.

Some alarming figures show up in the case of such big countries as Italy (1.5 %) and Germany (1.5 %). The slow growth rate is clearly related to the “sleeping position” of these countries (Siune in her contribution to this workshop).

If we compare these figures with those related to the proportion of researchers per 1000 workforce, United States has a larger proportion than the European Union (8.08 % vs. 5.28 %). But again, Finland is outstanding with a proportion of 10.62 %, while Sweden is following closely with 8.44 %.

Clearly, wealth as measured by GNP is a determining factor in influencing the number of available scientists. But for wealth to affect scientific performance, it must be translated into a set of other factors, not the least organisational and motivational ones. The richer a nation is, and the more it invests in higher educational reform, the wider is the array of educational courses and options open to students. Such wide options may very likely result in a diminished interest for science and technology; young talented students can now choose other non-science educational careers. Daniel Bell (1979) advanced the thesis of “the cultural contradictions of capitalism” as a real menace to the continuing advance of wealthy nations: students in wealthy milieus choose such educational careers that they find of immediate interest in satisfying their curiosity. These careers are more seldom science- and technology oriented but rather oriented to art and the humanities. Hence, a gap in the structure of motivation may account for the fact that these wealthy countries lack behind --- unless they can stimulate talents from other less developed nations or exploit their own “reserve pools”.

But what about Price’s polemic assertion that an exponential growth in the number of scientists as seen after the World War II affect the quality of science itself: as the average intelligence pool slows down, he expected there to be a diminishing return in the quality of science.

This polemic assertion is difficult to test, and the only measurements at hand here are those that relate to scientific output (published articles) and citation index.

Table 6. Economic Growth

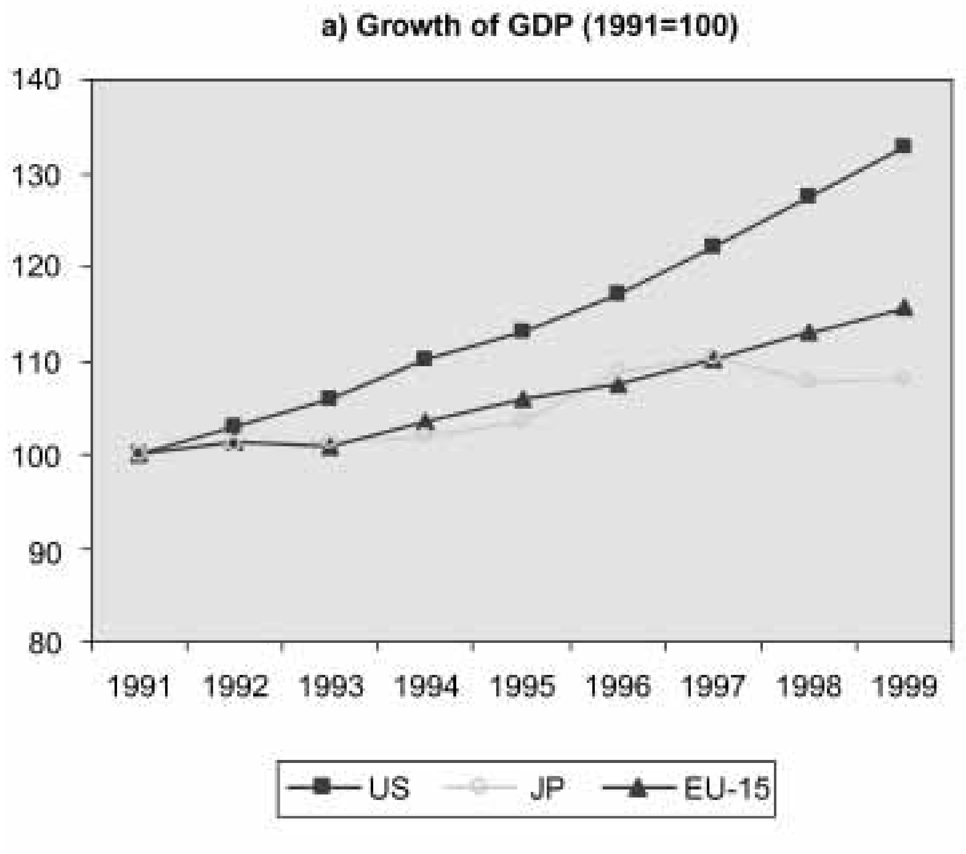
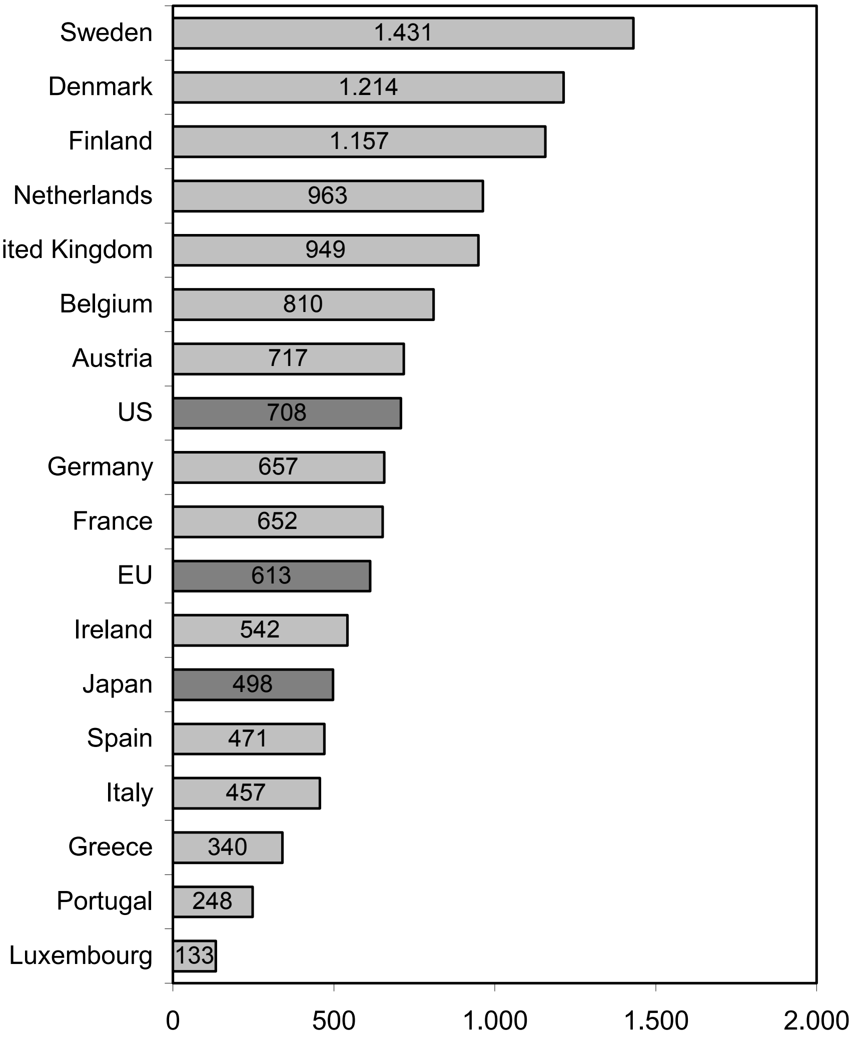


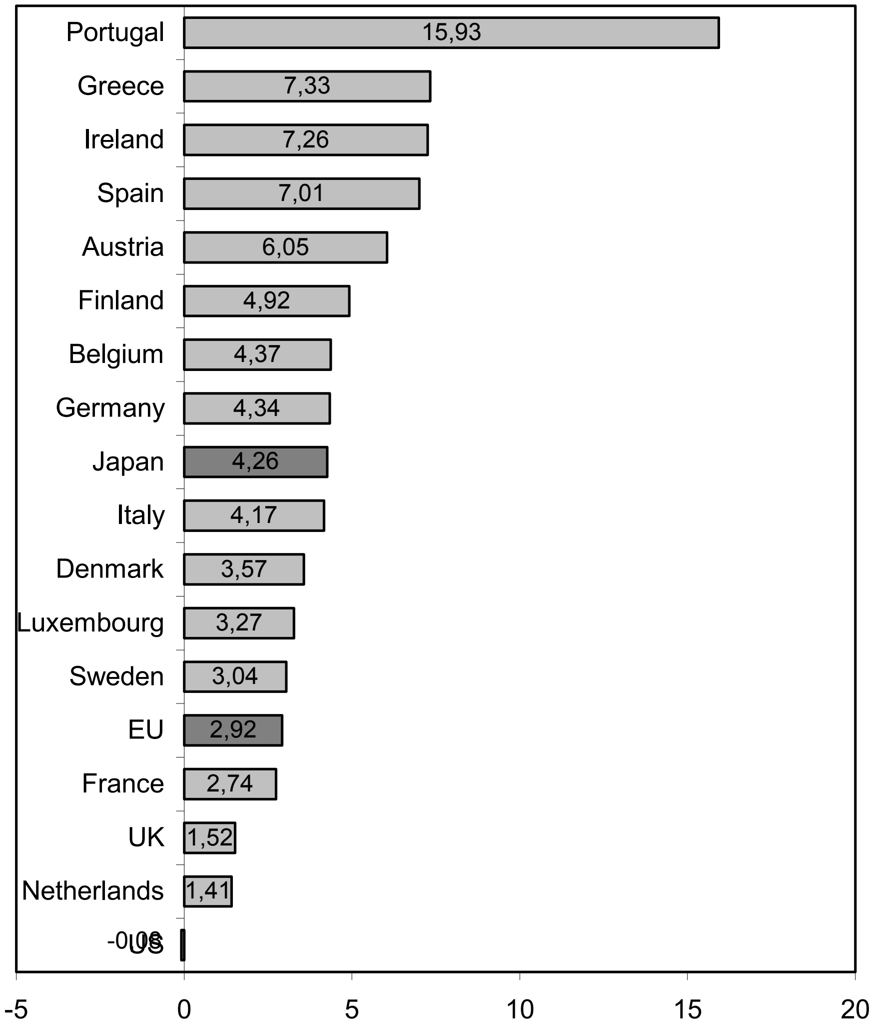
Table 7a, b: Scientific performance

Table 7a. Number of scientific publications per million population, latest available year (1)



Source: DG Research.
Data: ISI-SCI, CWTS (treatments).
Notes: (1) All data refer to 1999.

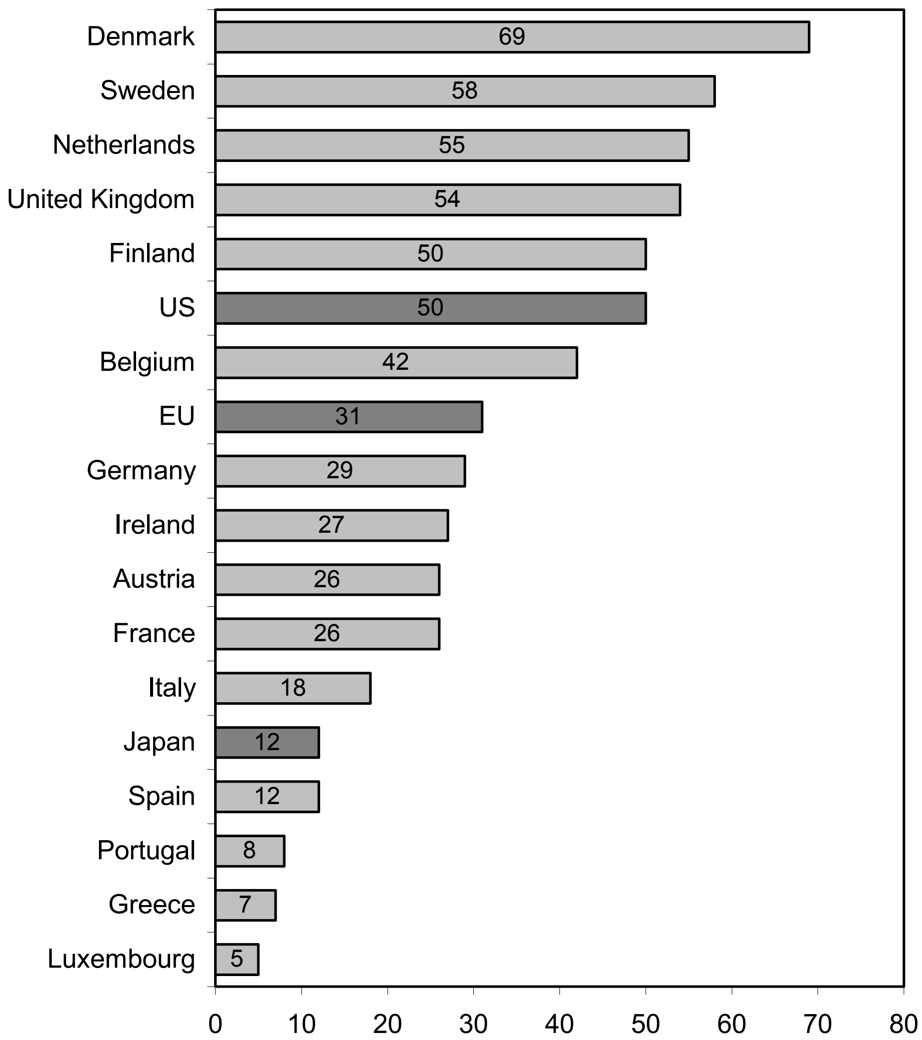
Table 7b. Average annual growth (%) of number of scientific publications, 1995 to latest available year (1)



Source: DG Research.
Data: ISI-SCI, CWTS (treatments).
Note: (1) All data refer to 1995-1999.

The Nordic countries are again in the absolute top lead. Denmark is even leading the citation league with the largest turn out of highly cited scientific papers per million populations.

Table 8. Highly cited publications



Source: DG Research.
Data: Eurostat, SCI, CWTS, Japan (Nistep).
Note: (1) All data refer to the period 1995-1997.

United Kingdom and the Netherlands are also in the top league in competing with United States. Japan has a very low share of highly cited papers, although Japan leads the patent league! The extraordinary position of the small countries with regard to the citation league should probably also be seen in the light of the very real language demands that such small language communities experience.

The problematic assertion that there is a diminishing value of scientific return in the case of highly advanced countries (USA – and more recently the Nordic countries) further rests on the assumption that these countries have no other "talent markets" to exploit but their own. In the case of United States, de Solla Price's predictions are clearly wrong; not the least because United States is the one supreme country in the world of student migration.

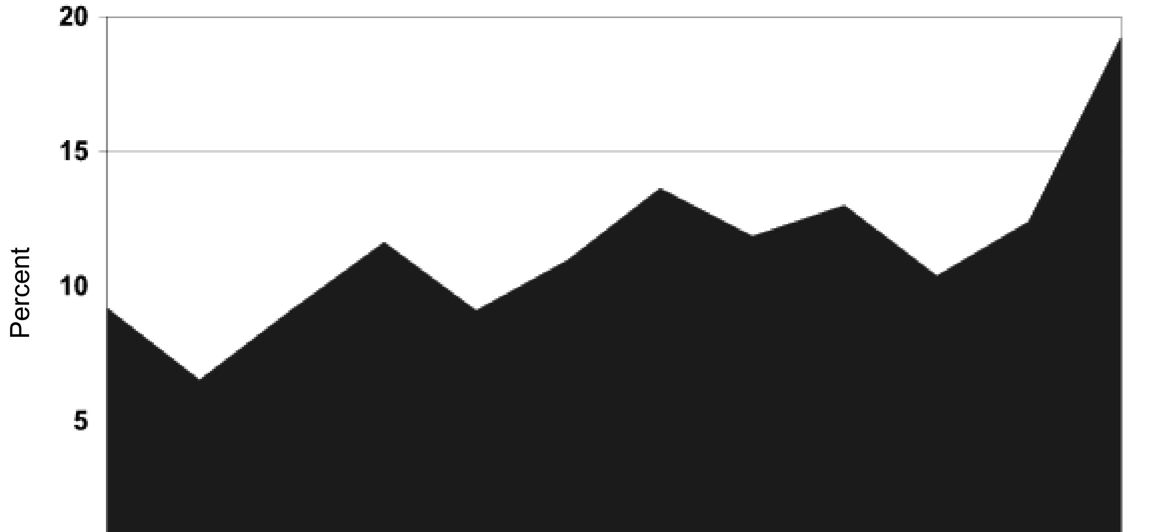
Table 9. Foreign students in USA

Country	Number
World	79,651
China	14,772
Japan	5,905
Germany	5,221
Canada	3,735
United Kingdom	3,352
Russia	3,253
France	3,154
Italy	2,226
Spain	1,706
Netherlands	1,037

Source: STRATA-ETAN expert working group. *Human Resources in RTD* (including attractiveness of S&T professions). 8 May 2002 (p 46).

In the case of the Nordic countries, foreign migration is clearly much less. However, in recent years also these countries are appealing to a number of foreign students:

Table 10. Foreign PhD students in Norway



Source: Doktorgradsregisteret, NIFU

It seems pretentious, to say the least, for any highly advanced country to claim that its own "intelligence pool" is exhausted – there are women, there are immigrants, there are always not yet exhausted pools of talents around not yet having access to privileged educational careers.

More problematic in the case of the wealthy countries, perhaps now also pertaining to the Nordic countries, is the motivational decline to pursue careers in the natural and the technical sciences. An immanent risk of wealthy countries resides in the "cultural contradictions of capitalism": privileged youth is more inclined to pursue careers where they can cultivate their own senses (Bell 1979).

Whatever are the prospects of “diminishing return” of wealthy countries in the long run to stay on the top, the prospects for those countries which have not yet exploited their intelligence pools (women, non-privileged classes, immigrants) seem the more promising in the case of Europe. However, such a promise depends upon the political and social will to reform and invest in mass higher education.

Conclusions

The scarcity of researchers in the case of Europe seems - in the light if this discussion – much more dependent upon social and political wills for organisational reforms of the higher education system so that young and bright people can pursue a scientific career without considerations of class, gender, and ethnic origins. The scarcity argument seems much less dependent upon the exhaustion of natural intelligence pools. If these pools are not sufficiently exploited – by means of social and political reforms – there will be a scarcity of researchers in Europe in comparison with United States and Japan. The Nordic countries have taken the lead, and as shown in recent statistics these countries can well compete and even outperform bigger and wealthier countries. The social welfare system pays off also with regard to R&D performance.

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4.2 Policy for Research Infrastructure: Some lessons from a comparative study of access to leading-edge research equipment

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Abstract

Continuing progress in science demands ever-higher performance standards from those universities who wish to remain at the 'leading-edge'. Also the competitive position of a nation's science base is affected by sufficient access to scientific research equipment for scientific researchers. Drawing on the perceptions and opinions of researchers and heads of departments at some of the most research-intensive universities in the UK and USA, we present key findings from comparative case studies of access to three different types of high-specification research equipment. Amongst the strongest arguments presented here highlighted the fact that funding of leading edge UK research groups should be less piecemeal and uncertain. Consistency and constancy of support are vital to nurturing high quality research. Also human resources and equipment acquisition are intimately interlinked but this is barely acknowledged in the context of present funding systems.

Introduction

It is acknowledged that the competitive position of a nation's science base depends on access to scientific research equipment, which is sufficiently technically advanced to enable scientists to carry out the experiments required to keep up with the leading edge of research. Such equipment must also be maintained in good working order, and provided in an institutional setting that allows researchers to make full use of it (PREST/ CASR, 2002). Scientific instruments may be usefully regarded as the capital goods of the scientific research industry. Therefore the conduct of scientific research generally requires some antecedent investment in specific equipment for purposes of enhancing the ability to observe and measure specific categories of national phenomena (Rosenberg, 1992).

Continuing progress in science demands ever-higher performance standards from those who wish to remain at the 'leading-edge'. Evidence suggests that the cost of meeting the performance level demanded at the scientific leading edge has grown at a faster pace than costs have been reduced through technological innovation, leading to a positive 'sophistication factor' for scientific research equipment (Georghiou and Halfpenny, 1996). The capital intensiveness of science has also increased through the growing number of fields requiring advanced equipment, notably the life sciences (Georghiou et al, 2001). For these reasons, research equipment has become a major science policy issue for many countries. For example, two substantial recent spending increases for science in the UK were largely justified by the need to renew decaying infrastructure and the policy shift behind these initiatives was directly influenced by data arising from surveys of scientific equipment commissioned from PREST (Policy Research in Engineering, Science and Technology) and CASR (Centre for Applied Science Research) at the University of Manchester (see Nedeva et al, 1999).

This paper draws on empirical research evidence obtained from conducting three comparative case studies of different types of high-specification research equipment. The strategy was to focus on three types of equipment in the most research-intensive areas of science, in some of the most research-intensive institutions. Due to the restricted timescale of this study we could only conduct a limited number of face-to-face semi-structured interviews with fifteen respondents based in UK and USA institutions. Therefore there is

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the scope to extend the comparative study element in the future by adding some mainland European nations and Japan, for example. As we compare the UK with the US situation it is worthwhile highlighting a few key science and engineering indicators produced by NSF (National Science Foundation) in the US. These indicators show that although Federal Government plays a diminishing role in supporting academic research, it still provides close to 60% of the financial resources. Fewer US institutions receive these funds. Research performing universities have increased their own funds, which now account for one-fifth of the total. Industry support has grown, but less than might be surmised given the close relationship between R&D and industrial innovation (NSF website, 2002).

Brief introduction to the scientific equipment cases

Three case studies were conducted that described experiences of UK and US institutions in funding, acquiring, managing, supporting and using one of three types of highly expensive research equipment.

These are:
1. High field Nuclear Magnetic Resonance (NMR) spectrometry (in chemical or biosciences research)
2. Electron-beam Lithography (in physical sciences research)
3. High Resolution Electron Microscopy (in physical sciences research).

1. NMR (Nuclear Magnetic Resonance)
Today NMR is a ubiquitous technique used for analysis of samples in the biological and chemical sciences, and low field NMR spectrometers are in use throughout chemical and biomedical research. The equipment and its use have continued to evolve, and ever-higher field NMR equipment is being developed. Access to high field NMR (currently 700 MHz, 800 MHz and 900 MHz machines) is particularly sought after by bioscientists, driven by the micromolecules they investigate. Today, high field NMR spectrometers are manufactured by three companies: Varian, Bruker (Germany) and JEOL (Japan). The high field NMR machines (typically 800 MHz) can typically cost between £1.5m and £2m. We interviewed heads of department and senior staff at the *Centre for Molecular Recognition* in the Department of Biochemistry at the University of Cambridge, the *Ley Research Group* in the Department of Chemistry at the University of Cambridge and the *NMR Group at Stanford University's* (USA) Department of Chemistry.

2. Electron-beam Lithography (EB-L)
E-beam lithography (EB-L) is the use of a beam of electrons not to generate an image (as in an electron microscope, to which e-beam equipment is closely related), but rather to cut a pattern in a substance. This is facilitated by the use of an extremely high precision movable stage on which the sample to be etched is placed. The ability to use a beam of electrons in this way is central to nano-scale research in integrated circuit design and in other fields.

This case study involved the selection of one E-beam lithography machine, which was the 'Raith 150' and this has a worldwide list price of approximately £550k to £800k depending upon the precise specification and options required. We interviewed heads of department and senior level staff at four institutions where the Raith 150 system has recently been installed. This is at the Department of Electrical & Electronic Engineering at the *University of Sheffield* (the only UK university to have installed the Raith 150 by the year 2001, the Centre for Integrated Systems at the *University of Stanford (USA),* Centre for Imaging Microscale Structures at *Harvard University (USA)* and the Physical Sciences Department at *Massachusetts Institute of Technology (MIT, USA).*

3. High Resolution Electron Microscopy (HREM)
HREM microscopes are designed to allow simultaneous atomic level observation and analysis and are an important tool for leading research in materials science. This instrument enables a variety of research activities to be undertaken including characterisation of nano-composite structures and nano-engineered

materials. The typical list price of the HREM type of equipment discussed in this case study ranges from £1.5m to £2m and more. We interviewed head of department and senior staff at the following institutions: *Manchester Materials Science Centre (MMSC)* – a joint department of the University of Manchester and UMIST; the Department of Materials at *Leeds University;* Center for High Resolution Electron Microscopy at *Arizona State University (USA).*

Identifying the need and purchasing the equipment

(i) From the *NMR case study* it was noted that the BBSRC had taken the decision to establish a national NMR facility for the UK in the mid-1990s, in response to an increased demand by researchers and Cambridge was successful in bidding to host this facility. This facility although playing an important role, only provides access to a single 800 MHz machine for the whole of the UK bioscience community. Users require long time periods on this machine. Therefore for a period of about five years the Cambridge facility remained the only UK group housing this NMR machine and this was at a time when leading US and European research groups would have had more ready access to such high field instrumentation. This lag still continues to exist now, with some other UK research groups receiving their 800 MHz machines (or at least placing them on order) whilst some overseas groups are now ordering 900 MHz machines (which can typically cost £3m to £4m). This sort of time lag is felt to hamper the competitiveness of UK research and according to our interviewees, the situation could be addressed by having a more strategic approach to the funding of research infrastructure in this cost range or simplifying the tendering requirements which may not be appropriate for the purchase of such expensive and sophisticated items.

By contrast at Stanford University in the US, the decision to purchase a new NMR machine would typically follow from the recognition by Faculty members that not enough NMR time is available for their needs, or because a higher specification device is required. In the US the NSF typically requires 15-40% matched funding from the institution or a private sponsor for the purchase of significant items of research equipment. NIH has no strict requirement for matched funding, but will often frown on its absence.

(ii) From the *EB-L case study* it was noted that Sheffield had identified a need to obtain E-beam equipment in order to fill a gap in their semiconductor research facility. When the EPSRC SEI (Strategic Equipment Initiative) opportunity arose, Sheffield prioritised the various internal bids in the university, and the Raith 150 machine bid was supported by several research groups across the university, all of which would be users of the item. The Sheffield interviewees argued that allowing UK research groups to put leading-edge research equipment items in place more quickly could in itself make a significant contribution to enhancing the international competitiveness of UK science. They also stated that significant costs involved in the pre-tendering process, which involve identifying the preferred specification and supplier and working out how an item would be funded, installed and supported is costly in terms of time and effort required from the principal investigators.

In the US, MIT opted to purchase a Raith 150 machine in order to ‘keep ahead of the nanotechnology wave’. This purchase was funded by a grant from DARPA (Defence Advanced Research Projects Agency) through the US Army Research Office. DARPA funded the purchase of the machine in addition to providing research program funding for MIT. At Stanford University they funded the purchase of their new Raith machine by piecing together funds held by different faculty members in departments like Electronic Engineering, Physics, Applied Physics, Materials Science and others with little or no NSF funds. The purchase of this machine was seen as a ‘stop gap’ measure until bigger funds become available to buy an even higher specification EB-L machine, which would cost approximately an additional $3m more than their current specification machine. This eventual purchase will probably be partly funded from an NSF grant and they hope to set up an endowment fund (possibly with a donation from a charitable foundation) to cover the purchase, support, maintenance and ultimately the replacement costs of the item. Meanwhile, Harvard University, whilst a very wealthy institution because of its massive endowment, has for contingent historical reasons tended not to have much of a presence in technology-intensive areas of scientific research. In recent years, however, a strategic decision has been made to redress this imbalance by investing heavily in ($200m) in three centres, of which one, the Centre for Imaging Microscale Structures (CIMS) will be housed in a new building with leading edge research facilities. Therefore Harvard were able to purchase a new Raith 150 system from the CIMS funds and money was not a constraint.

(iii) From the *HREM case study* it was noted that the Manchester Materials Science Centre (MMSC) had made a joint bid with the Corrosion and Protection Centre (based at UMIST) for funds from the Science Research Investment Fund (SRIF) to purchase HREM equipment. MMSC with their partners in Manchester identified a crucial need to have access to HREM equipment in order to enable further advances in ongoing studies in materials science areas that are of national and international significance. Also nationally, Manchester was no longer as well equipped as Oxford, Cambridge, Leeds and Sheffield and researchers had to be travel to one of these institutions to do high resolution work.

Leeds identified a need for an HREM facility because they believed that it was important for their competitiveness to have access to this facility, given that a number of comparable departments in US universities had already purchased this equipment about five years earlier. The grant obtained by Leeds also ensured that the group could support the running costs of employing a post-doctoral researcher for three years, which was a vital factor in their purchasing decision. As with the Manchester group, the Leeds facility enables access to HREM for other users in the university from Chemistry, Physics and Engineering departments.

By contrast, in the USA, materials science research centres like the Centre for High Resolution Electron Microscopy at Arizona State University are generally supported via the NSF, which funds small groups to multi-million dollar awards for 3-5 years to cover many professors, post-doctoral researchers and graduate students. However, competition for NSF centre funding is intense. A key feature of the US system is the availability of ‘start-up money’ through which a newly-appointed professor can agree the purchase by the university of expensive equipment during the course of his/her contract negotiations. Individual Principal Investigator grants for HREM in the physical sciences mainly came from NSF or the DoE, some of which might be spent on equipment purchasing. The three armed services also represent other important funding sources for university research in the physical sciences, and all support some equipment purchase.

Support and maintenance issues

(i) The *NMR case study* showed the importance of universities supporting a research facility where the equipment was purchased using an external grant. For example, the Department of Chemistry at Cambridge University had to make significant funds available to pay for part of the new building costs for housing an NMR facility and they had to agree to fund some posts associated with the running of the NMR facility (at the senior research officer level). This funding has proved to be very important in providing stability and continuity, in contrast with the previous situation in which the department was dependent on a steady flow of successive grant income in order to support these vital posts. By contrast at Stanford in the US, whilst the resources for purchase of instruments also comes from a mixture of government sources and university funding, the cost of the facilities in which the NMR equipment is housed is frequently met, fully or partly, by private donations from philantropic foundations. Every major new building carries the name of the donor. However, service contracts for maintenance support with equipment manufacturers can typically cost 10-15% of the purchase price of the item per year. This is extremely expensive even for an institution like Stanford.

(ii) The *EB-L case study* draws attention to the fact that in many UK universities, science funding at a departmental level tends to be very lumpy, with spurts of investment coming periodically. However, the long-term under-funding of the human resource component of the science base has meant that it is often difficult to find the required skills and experience when a sudden burst of investment takes place. Hence funds for both staff and equipment need to be maintained consistently in order to support excellence. For example, support staff for E-BL type equipment are required to be always present when such expensive equipment items are in use. But this brings to the forefront issues relating to the training and retention of support staff with the required skills to be always present when the equipment is in use. Sheffield University noted the difficulty of retaining suitable staff on a succession of short-term contracts funded by research grants. Therefore Sheffield will have to levy access charges on users to recoup support and other costs.

The US university interviewees did not seem to be subject to the same constraints in terms of human resources (particularly, but not only, on the academic side). At some of the US universities interviewed, academic researchers currently manage and support the E-BL equipment, with the support of technicians and it should also be noted that US universities pay salaries to graduate students. This is partly in order to support equipment items and facilities of this kind, and US laboratories therefore do not have the same need for non-academic technicians, as might be expected in the UK system.

(iii) The *HREM case study* demonstrated that HREM equipment investment must also be supported by investment in 'specimen preparation facilities[15]' and high quality support staff in order to operate and maintain this equipment. A key consideration in the purchase of a HREM microscope is the availability of a facility of adequate size and quality to house the item - this needs to be in place to avoid any operational or logistical installation problems arising. The building environment that houses this type of highly sensitive instrument must have the correct type of flooring and temperature control. Noise, vibration and electro-magnetic interference must be reduced to a minimum.

The most difficult cost in terms of post-purchase management is that of the maintenance contract. As with the other two equipment types covered by this study, the three HREM groups noted that manufacturers' service contracts are almost prohibitively expensive (a typical HREM contract might cost approximately £10,000 per year). If this contract includes spare parts then universities will seriously consider taking out the cover, given that many modern laboratory instruments now have self-contained units (e.g. electrical control systems) which have to be replaced as a whole even if only a small part has failed. However the judgement is always a difficult one. It was also noted that, when purchasing, it may often be possible to negotiate an extended period of cover beyond the usual one year. Some respondents felt that the best system would be to have local support staff fix minor problems after the contract expires, but for the University to take out some sort of 'contingency insurance' to cover the costs of any catastrophic problem.

Management and use issues arising

(i) The model by which the *800Mhz NMR* national facility at CCMR in Cambridge is operated was designed very carefully following intense discussions between the applicants and the research council (BBSRC). About 50% of the available equipment time on the facility is used by Cambridge researchers, with the other half being accounted for by external users, all of whom are UK academics. This split is controlled by an external management committee, which oversees this NMR facility.

One drawback noted at the Department of Chemistry in Cambridge is that although having the ability to contribute departmental funds to the purchase of the 700MHz NMR machine was seen to be very important at the time of the purchase. However, this decision has now left the department without funds to buy several lower-level equipment items needed to support a wide range of research across the department.

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[15] A specimen preparation facility provides a range of equipment necessary for microscope sample preparation. Typically this includes fume hoods, optical microscopes, polishers, evaporators, chemical etching equipment, diamond saws, heating furnaces, chemical storage and work space etc – all of which must be funded and maintained in addition to the HREM instruments themselves.

Unfortunately these are precisely the sorts of items which are often difficult to fund through research council grants.

The NMR case study clearly demonstrated that the modalities of the funding system have a strong effect on outcomes concerning management and use issues. A significant theme from the UK experiences was that of timing, with the concern voiced that the operation of the funding system was leading to unnecessary delays in the introduction of leading edge equipment into the UK research community. The delay between planning and submitting a proposal, peer review, hearing that the bid has been accepted, agreeing upon and entering into a tendering procedure, making an order, taking delivery, setting up and running in the equipment, can be a matter of years. Often, by the time an order is placed the list price of an item has risen significantly. One suggestion offered by an interviewee was that the research councils might consider early, informal communication about the chances of success of such proposals, in order to allow informal negotiations with suppliers to begin. It seems that this sometimes occurs in the US.

(ii) The *EB-L case study* demonstrated the fact that some research-intensive equipment facilities both in UK and US universities are run on the premise of maximising income generated rather than on supporting leading-edge research. At Sheffield it was noted that the pressure to recoup as much as possible of the start-up and on-going costs of the facility might lead to inappropriate use. Sheffield feel that it would be appropriate to restrict the use of their Raith 150 EB-L to leading-edge research work rather than to undercut commercial services simply in order to recoup costs more quickly[16].

Many US universities do allow supervised access to equipment by industrial users through an Industry Associates Programme or and higher charges will generally apply for such use. However, several US interviewees noted that the potentially ‘anti-competitive’ use of federally funded equipment for proprietary research for the benefit of one specific company (as opposed to industrially-relevant research which will be widely disseminated and may benefit many companies in a sector) remains largely unresolved by research funders and investigators. It should also be noted that the most effective – and the cheapest – way an industrial user can gain access to university research equipment is by collaborating with university-based researchers. This similarly applies in reverse (and, in the US, also applies between academic researchers and researchers based in National Laboratories).

At Harvard the point was made that charging schemes can never recoup the set-up and running costs of expensive items, and even modest charges for the costs of technical staff can have detrimental effects on research quality, with users rushing to complete their experiments in their allotted time rather than focusing on obtaining the best results out of the equipment.

(iii) The *HREM case study* highlighted an interesting ‘management of facility issue’ raised by Leeds is that the university is facing a dilemma in the future concerning the external transport environment and its impact on the running of their HREM. The problem is the plan to run a light rail (‘Super Tram’) system past the building that houses the HREM facility, which is likely to result in both electromagnetic and vibration disturbances. This equipment must therefore be relocated somewhere else in the university, and the institution wishes to recoup some of the costs of this from the local transport authority. As equipment of this kind becomes more sensitive to environmental interference the more sophisticated it is, such issues may become more significant in the future. To obtain the most effective use out of costly new facilities it would be sensible to choose a purpose built location well away from heavy transportation routes.

[16] For instance, EB-L equipment can be used to make photolithographic masks as well as to do direct writing onto a surface.

Conclusions

A strong theme to emerge from the UK cases was the difficulty of providing support for the leading-edge research equipment needed to keep researchers at the forefront of their disciplines in an uncertain strategic and funding environment. Welcome developments such as JREI, JIF and now SRIF (as well as research council based initiatives such as the Strategic Equipment Initiative) mean that it is now increasingly possible to win funding for major items of equipment. However, it is clear that the research equipment itself is only one component of a *package*. A major item of research equipment will typically require several 'complementary assets' including refurbished or purpose-built accommodation, skilled technical and user support staff, preparation and analysis facilities and the more generic, supporting equipment required to go with them. In essence the question is one of providing a service package which offers adequate and appropriately supported opportunities to use equipment which is maintained in excellent working order, even when it has to be recallibrated to meet the needs of a mixed group of users. It would seem that the barriers to providing such a service package exist both in the UK and the US, though the greater variety of federal, state and private funding options available for basic research in US universities may provide some cushioning within the US system.

It was strongly argued by several respondents that the funding of leading edge research groups should be far less piecemeal and uncertain. Consistency and constancy of support are vital to nurturing high quality research. This applies as much to the funding of technical and support staff (who are vital not only to support users but also to protect the precious machine) as to the other costs of research.

The potential for encouraging industrial use of academic research equipment, perhaps as a means of defraying the high costs of purchase or upkeep, would also seem to be fairly limited. Concerns about crowding out the leading-edge basic research for which the equipment item was funded in the first place, along with worries about subsidising commercial research with taxpayers' money (or undercutting commercial services with taxpayers' money) seem to outweigh any incentive to generate extra income. Indeed several of the interviewees noted that the simplest and most effective way for industrial researchers to gain access to university research equipment is by collaborating with academic researchers.

Finally, this paper fills a gap in the science policy academic literature by attempting to address the issue of access to large-scale research equipment by describing the experiences of leading UK and US universities concerning the issues of funding, acquiring, managing, supporting and using expensive research equipment via case studies based around three types of equipment. This study although taken from an UK perspective, also involved interviews undertaken at some US universities in order to provide a comparison with the world's leading research-performing nation. Therefore this study could also be extended to include a comparison with other leading research nations like Japan and other European nations.

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Chapter 5: International dimensions, changes and new challenges

5.1 Building RTD and Innovation capacity in the regions: objectives, priorities and means in the context of the European Research Area: *Synergies between Community actions: achievements, opportunities and limitations*

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Abstract

The progressive build-up of the knowledge based economy in Europe calls for increased efforts for building capacity for research, technological development and innovation in the European regions (sub-national entities). This is especially true not only in the less developed regions (better known as Objective 1 regions following the jargon of the Community Structural Funds) of the European Union (EU) but also in those areas going through profound economic restructuring (Objective 2).

Efforts to reach this goal have focused traditionally in providing and improving relevant infrastructure (university and laboratory space and equipment; improved communication facilities (transport infrastructure and telecommunications)) and energy provision. Today it is firmly believed that this policy, while necessary in the early stages of a process for building up capacity, is not sufficient and ultimately not sustainable if it is not coupled by a strategy that focuses on building technological and innovation capacity in a region in dynamic terms. EU past experience with both approaches (Structural Funds and the RTD Framework Programme via the RIS / RITTS/ RIS+ initiatives) makes it a world leader in supporting the knowledge based economy in the regions.

However major weaknesses are still encountered, namely on the delivery of these strategies and their successful articulation. While positive results may be registered in individual policies, sufficient synergies are not yet accomplished between respective Community initiatives. In the context of the developing European Research Area (ERA), the 6th Framework Programme for RTD (2002- 2006) will attempt a major mobilisation of actors at national and regional level, to increase this synergy and make the most of the available Community instruments.

This would be notably achieved through activities that will support and valorise the regional dimension of Community research actions in relevant areas of the 6th FP and policy development surrounding the progressive build up of the ERA. In particular these will focus on implementation of the ERA-Net scheme (co-ordination and mutual opening of research schemes and initiatives at national and regional level) as well as in other areas of the FP where the regional dimension may have an important role in stimulating or organising better research efforts.

Improved interactions will be sought between RTD instruments and the Structural Funds, notably the FEDER Innovative Actions.

[17] Disclaimer: “The views in this article are those of the author and do not express necessarily those of the European Commission”.

1. Introduction

The progressive build-up of the knowledge based economy in Europe calls for increased efforts for building capacity for research, technological development and innovation in the European regions (sub-national entities). This is especially true not only in the less developed regions (better known as Objective 1 regions following the jargon of the Community Structural Funds) of the European Union (EU) but also in those areas going through profound economic restructuring (Objective 2).

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This would be notably achieved through activities that will support and valorise the regional dimension of Community research actions in relevant areas of the 6th FP and policy development surrounding the progressive build up of the ERA. In particular these will focus on implementation of the ERA-Net scheme (co-ordination and mutual opening of research schemes and initiatives at national and regional level) as well as in other areas of the FP where the regional dimension may have an important role in stimulating or organising better research efforts. This article will review this strategy and will offer some strategy options to overcome identified pitfalls.

2. R&D and the Knowledge economy

During the last twenty years of the 20th century, the world's advanced economies have undergone profound changes in structural terms. These changes concern mainly the ways economies create value. Increasingly these are collectively known to be "knowledge-based". The term "knowledge based" in itself may be considered a false neologism, since one could argue that economies have been always "knowledge-based". However, the term is justified, because for the first time, knowledge is not only at the root of products and services found in the market: it is actually embedded into them. This embededness defines also to a large extent the competitiveness of artefacts that give to respective producer economies their comparative advantage.

This knowledge embededness is the direct implication of an ever faster growing accumulation of and reliance on formal scientific and technical knowledge affecting all sectors of the economy, with ever higher S&T content integrated in products and services and, as a consequence, need for more and better qualified human resources. These trends put increasingly pressure on education and training systems world-wide by raising the needs for quality standards, increased performance, more focused output and optimisation of available resources.

At the same time, knowledge has escaped its traditional barriers and travels freely across frontiers. Thanks to the availability of powerful technical means for producing, transmitting, storing and processing information through global information and communication networks, diffusion and use of knowledge, bring improved efficiency to economic activities around the world. The Global Research Village works around the clock with important implications for the world economy, not easily captured by statistics. E-commerce, especially on a business-to business basis (B2B), accelerate transactions and can ultimately create new rules in world trade, pushing laggards out of the competition. In addition, the increasing pace of trade liberalisation and flows of goods and services, push world economies to focus on more knowledge-intensive activities.

These trends describe a world where competition is brought back to basics: education and training becomes a sine qua non for keeping up with the increasing needs in knowledge follow-up. This is however not confined to individuals, it concerns whole economies, that is, nations and increasingly sub-national entities (regions). Local economies can be highly successful in keeping up with this pace, but dramatic failures may also occur, making whole regions redundant in terms of participation in the globalised world economy. In the European Union these trends are translated largely by the ever increasing gap between technologically advanced and lagging regions (Objective 1 regions in the terms of the EU Structural Funds).

3. The Lisbon Strategy and the Barcelona target

To face these trends, European Heads of State and Government meeting in the context of the European Council in Lisbon, under the Portuguese Presidency in the Council of the European Union, set themselves an important albeit complex and difficult vision: turn within 10 years (that is by 2010), Europe into the most competitive and dynamic knowledge based society and economy in the world, with more and better jobs, sustainable development, greater social cohesion; improvement of the labour market, better governance, improved life-long learning and people mobility. All this has to happen through the so-called “Open method of co-ordination and benchmarking”, a term that has been the topic ever since of many academic and political discussions (as it often happens with Community terminology introduced at the level of important policy discussions).

A proxy for the term “Open method of co-ordination” maybe that in principle it means that the process driving the “Lisbon Strategy” would be based on a loose co-ordination of efforts between Member States of the EU, that would not be governed by binding or uniform decisions, applicable to all players through Community legislation. Instead this has to based on the principle of a learning economy, and has to involve all players in a mutual learning process. This would also involve metrics via meaningful indicators to measure comparative performance, but would also include policy analyses to explain policy strategies and examine transferability of good practice.

The Lisbon Summit put Research and Innovation back on top of the policy agenda after a long under-representation as a priority policy issue. It also endorsed the proposed Commission strategy for building a European Research Area (ERA)[18] to achieve a more consistent and less fragmented European Research policy.

Later on, the European Council completed this goal by endorsing the Commission’s proposal for achieving an average of R&D investment at the level of 3% of GDP for all present EU Member States (Barcelona, March 2002). On this particular objective, the Commission has produced a new Communication[19] that outlines critical policy areas where action is urgently needed if this objective were to be met by the Member States. It is worth noting that action is expected at European, national but also at regional and local level.

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[18] “Towards a European research area”, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions - COM(2000) 6 (18.01.2000).
[19] “More research for Europe: Towards 3% of GDP”, Communication from the Commission. COM(2002) 499 final (11.09.2002).

With consistent efforts now being deployed around the Union, it could be argued that the ERA project became one of the cornerstones of the Lisbon strategy, towards building the knowledge based society in Europe. In this respect, it affects all policy levels, including that of the regions.

4. The interplay between Structural and Research policies

In order for the EU regions to respond to the Lisbon challenge, a consistent deployment of all Community policies has to be secured. This includes in particular the Structural Funds (European Regional Development Fund (ERDF) and the European Social Fund (ESF)) as well as the Community Framework Programme for Research and Technological Development. This is not new, since by definition Community policies complement each other in strengthening capacity for the regions.

Investing in infrastructure and equipment alone is not sufficient for advancing in the knowledge economy. Although the last decade has seen about 12 Billion Euro allocated to Research and Technology purposes in the European regions from the Structural Funds, the gap between technologically laggard and advanced regions is still growing. More than a decade ago, similar efforts in the EU have seen much success, through a number of schemes with an increasing emphasis on integrated strategies[20]. Thus it is worth to note that Community action is shifting from an “infrastructure-only” supporting mode to an “innovation-enabling”, a trend which has to be preserved in the context of the imminent enlargement of the Union to 25 countries, with a growing number among them in the “Objective 1” range (regions that the development is lagging behind), despite well foreseen pressures for the contrary.

The ERDF experience on Innovative Actions started with the old Article 10 of the previous Regulation whose basic idea relied rather on the principle *of helping regions to help themselves through initiatives designed to mobilise local knowledge in a process of collective social learning*. The philosophy of Article 10 has been summarised as follows (Messina, 1997[21]):

- Function rather an experimental laboratory
- Promote the innovative dimension of regional policy
- Promote partnership between the private and public sectors
- Enable the internationalisation of regions and local authorities
- Facilitate the transfer of know-how in the technical, economic and scientific fields between the regions of the EU
- Positive results of Article 10 projects should be incorporated in conventional regional policies.

It is striking to observe how far this philosophy remains of importance today (and how far it would still remain especially because of the enlargement context). Building innovative capacity in the regions has thus become a common endeavour of the Structural Funds and the RTD Framework programme over the years (notably through the Innovation and SMEs specific actions). This is now continued in the context of the new ERDF Innovative Actions (2000-2006) and a new regional philosophy embedded in the development of the European Research Area project.

It is also significant to observe that the effects of the Structural Policies to the economies of Objective 1 dominated countries (Cohesion countries) differ: a recent study conducted for the Commission services found that out of the EUR 135 Billion earmarked for Objective 1 regions from the STRF (2000-2006) one should expect an increase in GDP by 3.5% in Portugal, 2.4% in Greece, 1.7% in the Mezzogiorno, 1.6% in

[20] Regional Technology Plans, Regional Innovation Strategies, Regional Information Society Initiatives, Innovative Actions.

[21] “Competitiveness and European Regional policy: a review and analysis” Helen Lawton Smith, Centre for Local Economic Development, Coventry University, Gordon Clark and Paul Tracey, School of Geography and the Environment University of Oxford, http://www.regional-studies-assoc.ac.uk/events/lawtonsmith.pdf.

the former GDR and 1.1% in Spain. However these trends may also mean that the more advanced is a region (or a group of regions) the less impact the Structural Funds may have on the respective economy, since the productive base is less eligible for subsidies of this kind.

The interplay between the Multi-annual Community RTD Framework Programme and the Structural Funds is more complex, because the instruments are very different. First and foremost the Framework Programme has been traditionally an instrument based on a competitive approach and its main selection criterion has been by far scientific excellence. There are no national or regional quotas in the Framework Programme in contrast with the Structural Funds. Thus, whereas the Structural Funds apply a distributive policy based on national quotas, the FP organises open calls for proposals for transnational collaborative research projects linked directly to the research “performers” without any interference by national or regional governments. This reinforces partnerships between academia and industry at European level on the sole criterion of merit. Despite this, cohesion countries originating partners do surprisingly good in FP proposals.[22]

Complementarity between the two policy areas lies with the fact that the Structural Funds raise Research capacity in the regions by funding productive investment together with help to initiate strategies for R&D and innovation based on local assets. The FP “tests” this capacity by stimulating a competitive approach and connects the players together in concrete problem solving initiatives. The recent development of Regional Innovation Policy initiatives in the context of the 5th FP (Innovation and SMEs) confirms that a common ground can indeed be found between the two instruments, mainly based on strategy development. This trend will be further developed and consolidated with the 6th Framework Programme (2002-2006) that will develop a specific Regional Dimension for the European Research Area (ERA).

The European regional research landscape is rich in initiatives, with a wide range of players in the business and academic community. In addition many successful implementations of cross-border co-operation in R&D have occurred in the past, mainly through the ERDF INTERREG Programme, without forgetting more independent initiatives like the one of the so-called 4 *motor-regions*: Baden-Württemberg (D), Rhône-Alpes (F), Lombardia (I) and Catalonia (E) (on which a fifth should now be added / Wales (UK)). All this happens through a big number of players: Universities, businesses, local authorities, but mainly S&T parks that gather in one place universities, R&D organisations, multinationals, SMEs or laboratories.

Despite these trends, big regional disparities remain, as earmarked last year (January 2001) by the 2nd Cohesion Report. Cohesion countries technology gap with more advanced ones has widened and concentration in most indicators is general (in R&D expenditure, human resources and patent applications). In general regional patterns in these areas follow the national ones as can be observed in the 2 following tables (Data from EUROSTAT, Press release 31/2002, 13/3/2002).

[22] For example, in the year 2000, the 4 “cohesion” countries (Greece, Spain, Ireland and Portugal) have accounted for 16% of all Member States participations in the contracts of the 5th FP whereas at the same time they account for the 11% of the Union’s total research personnel. In financial terms 13% of the total of Community contribution has been allocated to partners coming from these countries, whereas their overall R&D expenditure does not represent more than 5% of the Union’s total.

Les dix régions européennes avec la plus forte intensité de R&D

	Pays	Région NUTS 2	Année	Dépenses en % du PIB	Dépenses en million d'euros courants
1	Allemagne	Braunschweig	1997	4,84	1.675
2	Allemagne	Stuttgart	1997	4,79	5.045
3	Allemagne	Oberbayern	1997	4,38	5.911
4	Allemagne	Tübingen	1997	4,05	1.608
5	Finlande	Pohjois-Suomi	1998	3,82	410
6	Finlande	Uusimaa (Suuralue)	1998	3,73	1.571
7	France	Midi-Pyrénées	1998	3,70	1.803
8	Rayaume Uni	Eastern*	1998	3,64	4.595
9	Allemagne	Rheinhessen-Pfalz	1997	3,50	1.527
10	France	Île de France	1998	3,43	12.416

* Region de niveau NUTS 1

Les 15 régions de l'UE avec le plus de demande de brevets de haute technologie par million dáctifs en 2000*

	Pays	Région NUTS 2	Demandes de brevets de haute technologie par million d'actifs	Demandes de brevets de haute technologie	Part des brevets haute technologie dans le total des demandes
	EU-15		**60,6**	**10.480**	**18%**
1	Allemagne	Oberbayern	540,9	1.132	37%
2	Finlande	Uusimaa (Suuralue)	530,4	416	52%
3	Pays-Bas	Noord-Brabant	524,2	633	40%
4	Suéde	Stockholm	430,0	416	40%
5	Suéde	Sydsverige	336,3	199	35%
6	Finlande	Pohjois-Suomi	321,1	86	54%
7	Royaume-Uni	East Anglia	236,3	265	39%
8	Finlande	Etelä-Suomi	202,4	188	37%
9	Allemagne	Mittelfranken	189,7	160	19%
10	Royaume-Uni	Gloucestershire, Wiltshire & North Somerset	169,6	197	39%
11	Royaume-Uni	Hampshire & Isle of Wight	169,0	156	43%
12	Allemagne	Stuttgart	162,9	315	12%
13	Suéde	Övre Norrland	160,5	39	35%
14	Allemagne	Oberpfalz	159,6	84	20%
15	France	Île de France	155,1	854	25%

* Données provisoires.

5. The Concept of the ERA and the Regional Dimension

The ERA concept represents in itself a new vision for European Research calling for less fragmentation of effort, the abolition of the 15+1 policy framework for European Research policies, an improved organisation for research at European level and a better use of scarce resources. As such it calls for a general mobilisation of all relevant actors including the European Regions. A new long-term partnership has thus to be established between all operators: the Union's Institutions, the Member States, the Regions, the Public S&T and the business R&D communities.

In this context the regions have to play a new role: an active, supportive one, largely pro-active, based on public-private partnerships, strengthening actors, providing infrastructure and means, bridging in general the gap between **knowledge creators and knowledge users.**

This will have to be implemented in a whole new environment, using a whole range of new FP instruments aiming mainly at integration of research capacity across all European regions. The new priority instruments (networks of excellence and integrated projects) have a special regional dimension as strong programming tools and potential cluster generators. These will be complemented by a whole range of "smaller" instruments that largely draw on the existing and tested ones of the 5th FP (1998-2002) and who are believed to be better accessible to the "smaller" actors of the FP.

The Framework Programme has been traditionally a policy planning tool for research and technological development at EU level. Historically it has been used as an instrument to promote transnational co-operation by supporting collaborative RTD. Now it will primarily serve to build the European Research Area, an endeavour that spans well beyond its short life-cycle. In achieving an "Internal Market" for research in Europe the FP will activate 3 blocks of activities, of which 2 are completely new: thus besides the "Integrating" area (that houses the thematic priorities) the "Strengthening the foundations of the ERA" and the "Structuring the ERA" blocks will have a structural role to play. It is important to note in this respect that together with Innovation, SMEs and the Human Factor, support will be given for the first time to develop initiatives in the areas of Co-ordination of Policies at national and regional level, Research Infrastructure and the interplay between Science and Society.

The concept of the Regional Dimension that spans across all these areas has been identified as important in all ERA related Communications right from the start. It has become also the target of a specific Communication by the European Commission, presented to the College jointly by Commissioners Busquin and Barnier in October 2001[23]. The message it delivered was primarily addressed to the Member States and was essentially that when they design National S&T policies they should be paying more attention to local and regional factors and operators, increasingly involving more the regions in a European policy context.

6. Enabling the European Research Area Regional Approach

6.1. Seizing the opportunities of the 6th Community Research Framework Programme (2002-2006)

The new Community RTD Framework Programme, presents regional bodies with a host of new opportunities, offering them diversified possibilities of participation and faster integration in the emerging European knowledge-based economy and society. These range from the newly introduced instruments of the Community RTD Framework Programme to activities that foster networking, transregional co-operation and a broadening of our knowledge-base concerning the regions' potential in terms of science, technology and innovation.

[23] "The Regional Dimension of the European Research Area" COM(2001)549) 03/10/01.

6.1.1. Taking advantage of the New Instruments

The new funding instruments for Community research actions emerge as key factors for structuring the European Research Area. In increasing the transparency and legibility of Community Research, they are expected to act as catalysts for the development of regional strategies, oriented on the one hand towards the regional economic fabric while remaining open to the European and international dimensions.

– Networks of excellence (to be set-up through calls for proposals), will allow for the reinforcement and integration of existing or developing scientific excellence in all EU regions. Bearing a strong programming character, they are expected to be particularly well adapted to regional research and innovation actors, allowing better connectivity between central and peripheral hubs of scientific competence, thus offering increased opportunities for collaboration, staff mobility, information and knowledge exchange as well as positive spillovers to the local and regional economies. In addition, efficient networks of excellence are expected to function as strong barriers against interregional brain-drain (scientists moving from less favoured to richer regions). They could contribute to build multi-polar areas of innovation and excellence, supporting indirectly local development and economic growth, thus contributing to regional population stability and acting against interregional brain drain

– Integrated projects, to be equally set-up through calls for proposals, will allow regional bodies to cooperate on a transnational basis around specific scientific and technological objectives, aiming at concrete results. Regional bodies may be associated here in transnational partnerships to develop specific projects, of a substantial scale, aiming at integrating scientific and technological efforts. Networks of excellence have as an objective the durable integration of research activities of participating organisations. Integrated projects will consist of a number of research components, executed in a co-ordinated fashion and allowing to partners to respond to societal or competitiveness problems. They will be managed in a flexible way and they will be open to participation to new partners. Both instruments aspire to drive the totality of European territory towards excellence, through association of all meritorious teams as well as the diffusion of research results.

Managing the new instruments within the context of priorities set by the Commission will be coupled with a number of consistent accompanying measures, ensuring that the funded activities will be in the service of a global strategy of progressive integration of European research.

Regions may also take advantage of the new co-ordination-type activities foreseen under the topic of "Strengthening the foundations of the European Research Area", using in particular the ERA-NET scheme.

Achieving greater cohesion in the Union, depends directly on the creation of the necessary conditions for the integration of research capabilities existing in less favoured regions in the European research fabric. The 6th Framework Programme intends to contribute to networking of regional capacity with a view to stimulate the setting up of real networks of scientific and technological competence and thus facilitate knowledge transfer. Activities supported under this strand of the Framework Programme will have a real Community added value, by virtue of their contribution to economic and social cohesion.

Conceived for both National and Regional levels, ERA-NET largely intends to encourage and support synergies between existing research activities in several regions through co-ordination activities at implementation phase, their mutual opening and mutual access to research results. It would also cover the definition and execution of joint activities. The Framework Programme could contribute to the co-ordination of research activities among research operators located in less developed regions and those located in the other regions of the Union, with a particular focus for those of them located in cohesion countries and in the outermost regions.

To this end the Community could support initiatives aiming towards networking activities by these regions, in accordance to rules foreseen for strengthening the foundations of the European Research Area. These would cover in particular targeted co-ordination actions, aiming at stimulating and supporting co-ordinated initiatives by different research and innovation operators in the countries and regions concerned. By way of example, they could comprise activities such as the organisation of conferences, meetings, studies, staff exchanges, exchange and diffusion of good practice, the setting up of information systems

6.1.2. Link more Research and Innovation at regional level

Encouragement and validation activities targeting local and regional initiatives will be developed, to promote development of new innovating businesses, transfer and exchange of best practice, as well as establishment of an environment more conducive to research and innovation.

– Trans-regional co-operation will be encouraged, to facilitate the development of research and innovation strategies as well as the initiation of programmes involving local actors. These activities will be developed in close co-ordination with those of the Union's Regional Policy and the Structural Funds.

– Particular attention will be paid to the participation of candidate countries ' regions to this activity type, notably in relation to the transfer of schemes that have proved to be successful at Union level to those regions. Moreover, innovative approaches and experiences will be introduced at national or regional level to study further the complex process of innovation.

The development of research and innovation strategies, as well as inter-regional technology transfer, have greatly benefited so far from significant assistance from the Community. The new Community RTD Framework Programme will be an important tool in continuing this effort. The European Investment Bank (EIB) and the European Investment Fund (EIF) may also prove instrumental, especially after their recent initiatives (I2I, Innovation 2000) and the mandates provided by the Stockholm, Nice and Lisbon European Councils for support to local and regional innovation initiatives through the provision of venture capital. The recent joint initiative between the Commission and EIB for reinforcement of RDT and Innovation initiatives by mutual supporting activities will also play in this respect an important role.

6.1.3. Develop more and better trained S&T human resources

Within the context of research training networks and the knowledge transfer fellowships to be developed under the context of Marie Curie human resources and mobility actions, opportunities will be offered to researchers originating from the less favoured regions, including re-integration grants. These very measures would also apply to researchers originating from regions of candidate countries.

Mobility and training schemes thus will focus on the development and transfer of research competencies, the consolidation and widening of researchers' career prospects, and the promotion of excellence. As the activity is in principle open to all fields of scientific and technological research that contribute to the Community's RTD objectives, accessibility is by definition guaranteed to all Union's researchers. However, the possibility of refining priorities, as regards for example, disciplines, participating regions, types of research organisations, and the level of experience of the targeted researcher populations, will be retained, in order to respond to the evolution of relevant European requirements.

Special attention will be paid to a number of factors affecting the socio-economic conditions of researchers, notably gender equity, linguistic balance and career structure. The development of research activities in the less-favoured regions of the EU and associated Countries will be taken particularly into account, complementing the efforts made in the context of the Structural Funds.

With a view to further reinforcing the human potential for research in the regions, HR and Mobility actions will aim to attract the best and most promising researchers from third countries, promote the training of European researchers abroad and stimulate the return of European scientists established outside Europe in their home regions (cf. point 3.4.1. above Investing in S&T human resources through the Framework Programme)

6.1.4. Support the development of scientific infrastructure in a regional context
Specific attention will be paid to the valorisation or the development of new scientific infrastructure in the regions, in collaboration and synergy with activities of the Structural Funds and the European Investment Bank. It has to be noted that modern scientific infrastructure is a key enabler of regional economic development (for example science and technology parks for efficient clustering and co-operation between academia and industry, or high-speed electronic networks and related facilities as a key gateway to the information economy).

A good example in this case is electronic research networking. The EU funded GEANT [24]broadband electronic interconnection backbone, already operational today (end 2002), linking all European electronic research and education networks with an average bandwidth of 2.5 Gigabits/second (and 10 Gbs at the core) including networks in the candidate countries, thanks to the Community RTD Framework Programme, bringing thus Europe for the first time in the lead in the field of electronic research networking world-wide. Additional support is expected to be provided by the EIB to regional and local upgrade networking initiatives, where appropriate. Researchers from EU less favoured regions and the candidate countries become thus able to cooperate under state-of-the-art conditions with their counterparts in advanced regions as well as with the rest of the world.

6.1.5. Reinforcement of the regional dimension of the Science and Society debate
The regional level may prove to be appropriate for undertaking support and reflection activities in the context of the emerging debate on Science and Society. Critical questions pertaining on the increasingly complex interactions between science and society can find a most fertile context for being discussed. The advent of the knowledge economy has caught many of the society's institutions unprepared to face the issues rising from several questions, brought specifically to the fore because of the advancement of science: questions around ethics in science, the frontiers of research and the role of science in governance are a few examples of the difficult topics that could be addressed also in a regional context and gain from its richness and diversity.

6.1.6. Reinforcement of Community policy for regional development by undertaking appropriate research
Within the context of the Anticipation of the Union's Scientific and Technological needs and to support other Community policies, specific support may be given to research activities in the field of Regional Development. The European Spatial Development Perspective scheme provides the general framework for a vast number of issues open to research opportunities, linked with regional development.

6.2. Increase the Science and Technology knowledge-base in the regions
In addition to activities foreseen from the regional actors' side, the Commission services will develop a pro-active policy in order to better develop understanding and knowledge about the different dimensions of research and innovation at regional level. This will aim in particular to:

6.2.1 Offer research and innovation services to the regions
Regional technology audits will be organised, with a view to better guide regional policy makers in their choices in terms of research and innovation. This proven method would provide analyses on the comparative advantages of regions and would allow policy makers set-up alternative scenarios in strategic terms.

The Commission will integrate the regions in its already undertaken benchmarking exercise in terms of performance of research and innovation policies. Extension of the scoreboards for research and for innovation to the regional level may also prove beneficial. This would be completed by the analysis of the

[24] http://www.dante.net/geant

context of regional research and innovation policies and the diffusion of best practice (synergies will be developed with similar ongoing exercises in this field e.g. RINNO[25]).

Designing successful policies requires sufficient backing from statistics; working on the regional dimension of the European Research Area would require adequate work on S&T statistics and indicators at regional level. In the past, the relevant Commission services have been active in the general area of regional statistics and a lot has been achieved but there's still work ahead in regional Science and Technology statistics: better methodologies, better concepts and a systematic incorporation of the regional dimension in the current surveys and data collections.

The statistical results achieved during the last decade are promising however it's clear that statistical indicators able to describe the characteristics, the structure and the performance of the Knowledge Based Economy are still lacking both at the national and regional levels. Based on such statistics appropriate science and technology indicators should be developed, at regional level.

The Commission will launch studies and analyses as appropriate, in the field of regional research and innovation strategies (two studies have been already completed, one on the topic of "Involving regions in the European Research Area" and the other on the R&D potential of the Outermost regions [26](RUP)). Topics would cover several related areas, for example industrial clusters, research infrastructures, but also legal, institutional and regulatory aspects, touching thus on policies and strategies related to regional development.

6.2.2. Improve communication between experts and policy and makers

The Commission will support the establishment of joint work and communication platforms between experts and policy makers at regional level. For example, groups of experts could be established in the field of technology foresight at regional level. The existing experience of projects like FOREN[27] could be used to guide further exercises in this direction.

6.2.3 Introduce a regional dimension in research and innovation information systems

The Commission will develop an integrated information system covering national and regional research and innovation programmes, targeted at policy and decision makers as well as researchers. This system, for which a feasibility study has already been launched, is a response to a specific demand by the Council and is expected to improve substantially the conditions for transregional / transnational co-operation in the areas of research and innovation, as well as the process of transferring best practice.

[25] http://www.rino.com.

[26] http://www.erup.net.

[27] FOREN (http://foren.jrc.es), is a thematic network under the Commission's RTD Framework Programme (STRATA, Strategic Analysis of specific policy issues) that aims at promoting effective integration of Foresight processes into regional development policy and strategy planning. It consists of a platform of experts and policy makers composed of representatives from two communities which are not used to work closely together: the technology Foresight community and the regional development policy community. Its objective is to create and exploit synergies and action-oriented co-operation between actors in the two fields, primarily through the simulation of Foresight-type activities. Experts and decision-makers representing both communities come from universities, research centres and other Foresight centres, as well as policy/decision makers from regional development agencies, regional/local authorities.

7. Towards more integrated strategies

Regions have by now come to be recognised at large as significant players in the drive-up to the knowledge-economy in Europe. Building on their developing qualities, experience and commitment, they will be increasingly present in Europe's efforts for growth and competitiveness. Enhancing this capacity and equipping them with the appropriate tools and strategies remains a challenge for the Union.

Regions are supported in their efforts by an increasing number of European policies, of which research and innovation and cohesion ones, emerge as decisive. While there is no doubt that cohesion policy is playing a major role for the regions, research policy remains instrumental for creating the necessary conditions for advancing the regions in the knowledge-based economy. Together with innovation and education and training, research brings a new message to regional economies, allowing for new forms of advancement, that keep pace with local but also international developments. Beyond regional development, regional research and innovation policies and initiatives may provide the essential ingredients for the emergence of agglomeration economies and of successful industrial clusters.

The key message of this article is thus, that European regions may now prepare to fully play their part in the new European and global economy, by developing consistent agendas in research and innovation. To this end, integrated strategies supported by relevant Community policies (as it is the case with research and cohesion policy) will bring faster results, interconnecting regions into the fabric of a truly European Research Area.

5.2 Towards 3% GERD and impact on Capacity Building

Mike Rogers, Commission of the EU, DG Research[28]

The interest of economists in innovation is largely due to the influence of Joseph Schumpeter and his writings of 50 years ago. Innovation was, for the first time, recognised as a key mechanism in wealth generation. Baumol[29] has now reinforced that vision while recognising the role of technology as a fundamental driver in its own right, as well as a key technology to creating a dynamic conduit for the innovation process itself.

The Source of the 3% Target

The role of R&D as a driving force for a competitive and dynamic knowledge-based economy is linked to the economy's capacity to turn new knowledge into technological innovation, and though the increased importance of investing in R&D is recognised, it is only efficient to do so to the extent that the exploitation of results are effectively and coupled with sufficient expectations of returns to balance the risk.

At the Barcelona[30] summit of Ministers agreed to set a target of increasing R&D investment in the EU from a current 1.9% of GDP to "approaching 3%"[31]. Some studies report[32] that just 20% of the total economic benefit of innovation accrue to those who invest directly, making it attractive to wait to benefit for spill-over from someone else's investment. Therefore more attractive "framework" conditions are essential if Europe is to achieve these investment objectives. Among the most important in this regard - apart from the prospect of profit - are a sufficient supply of highly qualified human resources, a strong public research base, a dynamic entrepreneurship culture, adequate systems of intellectual property rights, a competitive environment with research and innovation-friendly regulations and competition rules, supportive financial markets, macro-economic stability and favourable fiscal conditions.

There is also a case for a more effective and focused use of public financial incentives to private R&D and technology-based innovation, within the context of State aid rules and of the Stability and Growth Pact[33]. So enhancing public support for R&D must to a large extent come through restructuring of public expenditure. Public authorities have a range of financing instruments at their disposal, such as direct support measures, fiscal incentives, guarantee schemes and public support for risk capital. A mix of these instruments is required, depending on national and regional and sometime even local situations. At the same time, schemes have to meet the requirements set by the WTO[34]. Yet in order to reach such goals; it is recognised that the majority of investment has to come from the private sector, so public schemes must leverage such investment.

Several recommendations to set firm objectives had been put forward in recent years, notably by the European Parliament[35] and the Economic and Social Committee[36]. It is also supported by quantitative objectives to increase R&D investment that have recently been set in several Member States[37].

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[28] Any contribution or opinion expressed here are those of the individual and not of the Commission, nor bind the Commission or any of its related institutions in any way.
[29] W Baumol, "Free market innovation machine – analysing the growth miracle of Capitalism', Princeton University Press.
[30] Which followed up the Lisbon Summit of March 2000 where the Union set its goal to become the leading knowledge based economy in the world.
[31] The 3% is to be taken as an average across all EU-15 states.
[32] The Grwoth machine, The Economist, May 18th 2002, pp82.
[33] Which keeps the Euro-zone economies in a policy envelope.
[34] World Trade Organisation.
[35] "Report on the communication from the Commission *Towards a European Research Area*", *Session document*, European Parliament, A5-0131/2000, 9 May 2000.
[36] J.O. C 204, 18 July 2000, p. 70.
[37] In Austria, Denmark, Finland, Greece, Ireland, Luxembourg.

"Approaching 3 %" is an EU wide target and implies a major increase in European R&D Capacity, but there is little said about where that comes from. Also, not all current and future[38] Member States will meet this target individually by 2010 but they should all contribute to the effort. If the Education system reformed tomorrow then it may just help to impact the picture by the time the Lisbon targets are to be met.

GERD = BERD + GovERD[39]

More than 80 % of the R&D investment gap with the United States[40] lies with the funding levels of the business sector. So Europe calls for an increase in the level of private sector funding, which should rise from its current level of 56% to 67% of total R&D investment, a proportion already achieved in the US and in some European countries. Investment in R&D will only rise if it is attractive and profitable to do so.

Comparison of R&D expenditure in the EU and in the US shows a massive and rapidly growing gap, both in value and as a share of GDP - the gap has doubled at constant prices since 1994[41]. The bulk of the R&D gap (>80%), and most of its increase in recent years, is due to lower funding by the EU business sector. The US government devotes almost a third of its R&D funding to support business R&D, compared to only half that share (16%) provided by public funding in the EU. Japan[42] already devotes 3% of its GDP to R&D, with the business sector accounting for 72% of R&D expenditure in Japan[43].

Output indicators suggest that labour productivity gains in Europe, partly driven by innovation, have slowed down in the EU during the second half of the 1990s, while they accelerated in the US during the same period[44]. Trends in international trade of high-tech products point to European weaknesses in the competitiveness of some technology-based segments of the economy.

Industrial Sectoral Structure

The structure of industry in the US is considerably more specialised in high-tech and research intensive sectors than is the case in the EU[45]. A large part of the difference between the US and the EU is coming from the defence industry and from ICTs.

Structural effects cannot explain fully the difference in R&D investment between the US and the EU. In most sectors, including medium and low-tech manufacturing as well as the services sector, European firms invest less in R&D as a proportion of sales than their US counterparts. EU enterprises tend to specialise in less technology-intensive products and services, and so risk losing competitiveness to more innovation-intensive rivals, notably in the non-high-tech sectors which still constitute the bulk of the EU economy.

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[38] The 13 Accession States are all significantly below target, and will have the greatest ground to make up. The 10 for the first wave feature the best prepared ones though.
[39] Although in some countries, not for profit private sources can be significant factors too. In the UK, the Wellcome Foundation alone contributes 1 billion Euro towards UK R&D spend annually, while also operating in 3à countries. BERD is used loosely, not distinguishing if Business merely funds or executes the research itself internally-– the important issue is for business to invest.
[40] Which is 2000 was running at 120 billion Euro for the EU15.
[41] R&D intensity in the EU, measured as the percentage of GDP accounted for by total investment in R&D, stagnated at around 1.9% over the last ten years, while in the US it grew continuously from 2.4 % in 1994 to 2.7 % in 2000.
[42] However, there are significant limitations to a comparison with Japan because of the differences in the roles of the public and private sectors, and the problems of the Japanese financial system.
[43] Compared to 56 % in Europe and 67 % in the US.
[44] European Commission, *Productivity: The Key to Competitiveness of European Economies and Enterprises*, COM(2002)240, 14.05.2002.
[45] See also Commission Staff Working Document, *European Competitiveness Report 2001,* 2001.

Multinational companies account for the greatest share of business R&D expenditure, but they tend to invest based on analysis of locations[46]. So the growing concentration of transnational R&D expenditure in the US is a source of concern, suggesting a decline in the global attractiveness of the EU as a location for R&D as compared to the US[47], and probably accelerated by the events of 9-11 after which US companies include security for staff and plant as an additional factor.

Diversity of national and regional situations

EU countries and regions[48] are starting from very different levels of R&D intensity, from around 1% of GDP or less in Southern Member States, to 3.4% in Finland and as high as 3.8% in Sweden. Differences are even greater between regions within countries. Trends of R&D intensity also vary, with rapid growth in the Nordic countries, Ireland and Austria; while the share of R&D investment in GDP decreased in France and the UK - though investment measures announced in August 2002 for the next 3 years will ensure good progress to the target. Business R&D is above or close to two thirds of total expenditure in Finland, Sweden, Germany, Belgium and Ireland, while it is less than 30% in Greece and Portugal.

Accession states R&D investment is progressing. They have an average R&D intensity of 0.7% of GDP, similar to the levels of Greece and Portugal, with the Czech Republic reaching 1.25% and Slovenia 1.5%. However, the share of business funding remains very low overall. Any impact on public sector capacity building is likely to be higher there. Some countries have set ambitious targets. Greece, for example, has in the context of Lisbon, aimed at a near doubling of its GERD over the next 5 fiscal years, aiming to attain 1.5% of GRED as an intermediate milestone.

Areas for concerted action

An array of policy framework conditions must be brought into play to reinforce the attractiveness and profitability of R&D investment. More attractive framework conditions include

- access to a sufficient supply of quality human resources,
- elasticity in the system,
- a strong public research base,
- an entrepreneurial culture,
- adequate intellectual property rights systems,
- a competitive environment with research,
- innovation-friendly regulations and competition rules,
- supportive financial markets,
- favourable fiscal environments and macro-economic stability

are all essential.

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[46] "Assessing the Impact of Technology and Globalisation. The Effects of Growth and Employment", *European Commission research project*, 5th Framework Program (IHP), AITEG, 2000-2002.
[47] In 1991, both the US and the three larger EU countries (France, Germany and the UK) attracted around 45% of all cross-country business R&D investment in the OECD area. In 1998, those three European countries attracted only 35% of cross-country investments whereas the US share had soared to 55% (OECD, *Measuring globalisation - The Role of Multinationals in OECD Economies*, 2001).
[48] Here "regions" refers to sub-national entities.

Sufficient and appropriate human resources

R&D is particularly labour intensive - especially in knowledge based sectors - the lack of human resources is a major constraint on the EU's capacity to deliver. Even at current R&D levels, the recruitment of new researchers to replace those retiring will be difficult in some EU countries due to their relatively older S&T workforce, especially considering the worrying decline in the attractiveness of some natural sciences, engineering and technology curricula among students[49]. The problem will be aggravated if the demand for researchers outside Europe also grows and the net outflow of S&T human resources from Europe - to the US primarily[50] continues. Fortunately there are signs that this may be slowing slightly. Also, the first wave of planned enlargement in 2004 brings some potential capacity into the EU system.

The EC has presented a strategy to create a favourable environment for the mobility of students[51] and researchers and has set out a series of actions to build up R&D competence and excellence, while taking into account the specific situation of the regions lagging behind[52]. Detailed objectives for education and training systems in Europe have identified a number of actions in relation to recruitment to scientific and technical studies[53].

Possible policy areas for review with a view to developing proposals for action
Assessing, raising awareness of skills needs and future career opportunities in different S&T areas;

- Assessing the capacity of the educational and training system to respond to those needs, in co-operation with private and public sector employers and suppliers of scientists and engineers.
- Encouraging further women to enter S&T careers[54].
- Encouraging further the development of networks of excellence for higher education and R&D.
- Encouraging the development and visibility of S&T careers in Europe, in enterprises and in the public sector.
- Developing better reward structures and career paths for young scientists.
- World class research equipment.
- Facilitating life-long learning and transfer of knowledge.
- Better career development through the mobility of researchers within Europe.
- Facilitate the entry of third country researchers by removing administrative obstacles.

[49] See European Commission's "Action Plan on Skills and Mobility in Europe" COM(2002)72 of 13 February 2002 and the STRATA-ETAN expert working group, op. cit.
[50] Although this will require further study, European students are known to represent 36% of foreign students in the US, 60% of whom are still present in the US five years after they moved. For a study of trends in the late 1990s see S. Mahroum, "Europe and the challenge of the brain drain", *IPTSR* n°29, Nov. 1998.
[51] 1 million students have now been supported for cross border mobility in the past 10 years by EC programmes, see keynote speech by M Guiterrez-Diaz, Educational Benefits of ICT; OECR, Rotterdam, Sep 2002.
[52] COM(2001) 331 of 20.06.2001.
[53] Official Journal C142 of 14.06.2002.
[54] According to the STRATA-ETAN expert working group, *Benchmarking National R&D Policies - Human Resources in RTD*, May 2002, women currently only represent between a quarter and third of researchers in EU countries.

HR Capacity as the basis of Intellectual Capital[55]

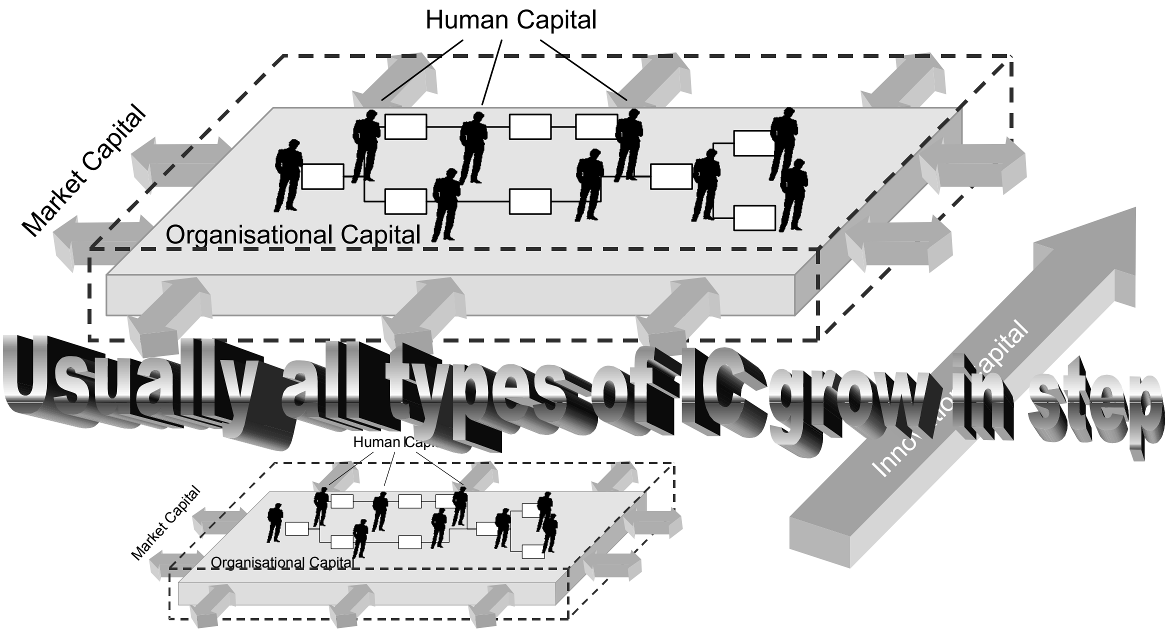
Handling knowledge becomes a decisive competitive factor and a determinant variable in the knowledge creation value chain[56]. Studies show that in a customer-driven environment, which PRO's are increasingly faced with, up to 75% of added value comes from the generation of Intellectual Capital[57,58] by researchers. So it is important to efficiently exhaust their knowledge potentials, i.e. achieve knowledge advantages[59]. Equally, product and service development has a special position in the value chain. It represents a leverage function for future development, thus for the market competitiveness of an organisation[60], to some 70% - 80% of future competitiveness.

In such development, all available and necessary internal and external knowledge – preferably codified - has to be bundled in order to define product attributes and functionalities in line with the market. Knowledge is used in this process, in the product and as product. Therefore the strategic relevance of Intellectual Capital and its evaluation is considerable in product development.

Intellectual Capital and its components

For a better understanding, Intellectual Capital can be divided into four categories: Human Capital, Organisational Capital, Market Capital and Innovation Capital.

Figure 1: Categories of the Intellectual Capital



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[55] Measurement System For the evaluation of Intellectual Capital, Dipl.-Ing. Kristina Wagner, Dipl.-Ing. Ilja Hauss, *Institute for Human Factors and Technology Management (IAT), University of Stuttgart, Germany,* Leena Saikkonen, Timo Koistinen, *QPR Software Oyj, Helsinki, Finland,* Mag. Andrea Polterauer, *Profactor Produktionsforschungs GmbH, Steyr, Austria.*

[56] Stehr, N. (1994). Arbeit, Eigentum und Wissen: Zur Theorie von Wissensgesellschaften;: Suhrkamp, Frankfurt am Main.

[57] Arthur Andersen, Next Generation Research Group (1998). Knowledge Measurement: Phase Three - Global Survey Findings Report; Next Generation Research Group.

[58] Bullinger, H.-J.; Wörner, K.; Prieto, J. (1997). Wissensmanagement heute, Fraunhofer-IAO Studie; Stuttgart.

[59] Eversheim, W.; Klocke, F.; Pfeifer T.; Weck, M. (1999). Wettbewerbsfaktor Produktionstechnik: Aachener Perspektiven, AWK Aachener Werkzeugmaschinen-Kolloquium (Publisher), Shaker, Aachen, pp. 73-97.

[60] Bürgel, H. D.; Haller, C.; Binder, M. (1996). F&E Management, Vahlen, München, pp 28 ff.

Human Capital reflects the ability and capability of company employees to react to market demands and apply solutions to customer needs. Thus the Human Capital comprises competencies such as skills, expertise and talents but also attitudes like leadership and management issues as well.

Organisational Capital reflects the capabilities of the organisation to provide products and services to the market. In a sense it comprises the environmental variables enabling the exploitation/maximum productivity of human potential. Therefore the Organisational Capital refers to processes, infrastructure, culture and relationships and management issues.

Market Capital comprises the strengths and the capabilities of the company in terms of the stakeholders, respectively the customers and the suppliers. On the one hand it comprises the capability of the organisation to recognise market demands in advance, which means to launch new products and services at the right time with the right features. On the other hand it comprises the interactive capabilities with the external interfaces. Therefore Market Capital contains all market related competence, customer issues, supplier issues and relationship issues.

Innovation Capital refers to the capabilities of an organisation to generate value in the future. This comprises the capability of an organisation to continuously improve and develop the potentials of the entire organisation. It contains therefore all the components in the development of processes, products and services along with technology and management issues.

The key issue is that al these forms of capital are underpinned by human resources, by capacity to do research and to develop and use knowledge brought in, generated and exchanged within a laboratory. Whereas laboratories without walls are feasible, without people is not! So the capacity of the systems has to be reflected in indicators of measurement of Intellectual Capital relative:

1. The basic potentials of the organisation (Human Capital)
2. The ability to transfer this potentials to products and services (Organisational Capital)
3. The competence to manage and to integrate the external interfaces with the organisation's stakeholders (Market Capital)
4. The capability to improve and develop continuously all potential and environmental variables.

In the case of certain public laboratories, it can also be important to have a basic core competence which is not much subject to market forces – like metrology – which can be used to generate additional capital in the categories above without adding to the cost base.

Improved academia-industry links

The excellence and scale of Europe's science base, including long-term research, are critical for the dynamics of the knowledge-based economy. Poles of scientific excellence around public research institutions tend to have a powerful leverage effect on R&D investment by all kinds of enterprises in the area, including enterprises which would otherwise not invest in R&D. But science-industry relations in the US have notable track records[61].

Regional authorities are playing an increasing role in attracting R&D related investment from abroad and R&D investment exceeds 3% in some regions[62] which have put a strong emphasis on research and innovation and achieved an effective mix of public and private partnerships.
Facilitating mobility of researchers between public research and the private sector is also an important means of improving networking between public and private R&D in the EU.

[61] Affinity & Proximity, Prof Hans Weiler, Keynote Address OECR Conference, Rotterdam Sep 2002.
[62] Though probably these are less than 1 in 10 of the 400 plus NUTS-2 Regions, and none in the Accession States.

Some research shows that start-ups from academia take longer to come to profit. They need more capital, a wider set of support services and generally 3 years to turn a profit[63]. This key reason is the constant overestimation of the market readiness of the technology on which it is founded by the academics that developed it.

Possible policy areas for review with a view to develop proposals for action[64]

- Establishing clearer and more consistent priorities for public R&D.
- Systematic participation of industry to planning and foresight in relevant industrial or technological sectors.
- Encouraging public-private R&D partnerships.
- Supporting leading for knowledge transfer and commercialisation of R&D results[65].
- Initiatives to strengthen the public research base and industry links for EU's regional and cohesion policies.
- Opening national R&D programmes more to trans-national collaborations.
- Removing obstacles to university-industry researcher mobility.
- Addressing transferability of pension rights and mobility as an element in career progression.

Entrepreneurship

Entrepreneurship is extremely important in creating high-growth companies that create value from R&D investment and that are also new R&D performers. Spin-off companies in particular have been a key routes for exploitation. Europeans are much more cautious than Americans when it comes to creating new businesses[66], largely because the taint of failure is long lasting and often commercially fatal. The Commission is preparing a Green Paper on entrepreneurship[67] addressing these issues.

Participation in public collaborative R&D programmes is an entrepreneurial act, and these are reported as having a major influence on the launch of spin-off companies and on their early growth by facilitating the establishment of strategic links[68]. Spin-offs from public research are being increasingly encouraged at regional, national and EU levels, by supporting training activities[69] in addition to science and technology parks and business incubators. R&D-based entrepreneurship is favoured by a high level of scientific and technological literacy and a culture of trust and understanding in the relations between science and society[70].

Possible policy areas for review with a view to developing proposals for action

- Promoting high technology ventures linked to public sector research.
- Promote co-operation with the risk finance community and development of management skills.
- Develop management skills in relation to intellectual property rights and technology transfer.
- Support spin-offs from larger firms.

[63] VDI Trendletter, No 37, “Start-ups”.
[64] These areas for action should also be considered in relation to public financing of private R&D (see 3.2.1.).
[65] Recent examples of large public-private R&D partnerships include the joint undertaking for the European satellite navigation system Galileo. Examples of regional R&D clusters include, among many others, a cluster in electronics and other fields developed around Oulu University in Finland, biotechnology clusters in the three German "BioRegios", and several clusters in the transports sector in Andalusia.
[66] See European Commission *Flash Eurobarometers* n° 107, November 2001, and n° 81, October 2000.
[67] This will consider aspects such as the simplification of company registration procedures, regulations covering bankruptcy and the promotion of business education.
[68] P Moncada, A Tübke, J Howells and M Carbone: "The Impact of Corporate Spin-Offs on Competitiveness and Employment in the EU", *IPTS-Report*, n° 44, May 2000; and M Meyer, “Start-up support and company growth”, *IPTS-Report*, n° 51, February 2001.
[69] Such as those supported under the European Social Fund.
[70] See the “Science and Society Action Plan” of DG RTD.

Effective adaptation and use of IPR[71]

IPRs such as patents, copyright, trade secrets, design - are an increasingly important factor in defining rules of the knowledge based game in research collaborations and technology transfer among firms, and between industry and public research organisations, in scientific and technological co-operation agreements between countries and in international agreements.

The increasing importance of intellectual property to firms can be seen in the growth of patenting activity and earnings gained from the licensing of technology. Contrary to popular belief, most companies do not use IPR to control and constrict technology to optimise their own revenue, but more usually licences technology to others to create a market, especially if others can exploit the innovation more efficiently.

IPR systems are complex and are evolving rapidly in response to the need to adapt protection to new technological areas and to demand by intellectual property owners for legally safer, stronger, more harmonised and better enforced international standards of protection.

A range of measures have been adopted or proposed to establish a more effective and unified IPR framework in the EU. These include an affordable and legally certain Community patent, patent protection of biotechnology and computer-implemented inventions, copyright for the digital age, protection of databases and of designs. National attitudes towards European level IPR need to be reformed in the light of globalisation, otherwise the rate of diffusion and application of new knowledge in Europe will be bounded by the rate and cost of protection.

At the international level, the protection and enforcement of IPR through the implementation of the WTO TRIPS[72] agreement and the WIPO[73] conventions are critical to the development of trade, international R&D collaboration and technology transfer, though the role it plays in the development of poorer economies has to be recognised[74].

National rules governing the ownership and management of IPRs arising from publicly funded R&D and IPR arrangements and related financial aspects in university-industry collaborations vary considerably across Europe and within countries, and are an impediment to the development of trans-national public/private collaborations and technology transfer.

Possible policy areas for review with a view to developing proposals for action

- Improving the IPR legal framework.
- Dealing with the evolution of technology and the world-wide harmonisation process.
- developing new IPR arising in particular from technological advances.
- Pursuing international harmonisation and enforcement of IPR systems.
- Helping least developed and developing countries build their own capability.
- Promoting mutually beneficial R&D collaboration in areas of common interest.
- Promoting good IPR practices in publicly funded collaborations.
- Promoting effective management of IPRs by producers and users of knowledge.
- Awareness raising, training scientists/engineers, development of support services.

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[71] Intellectual Property Rights.
[72] Trade Related Intellectual Property Agreement under the World Trade Organisation, which establishes minimum standards for the protection and enforcement of IPRs.
[73] World Intellectual Property Organisation.
[74] “Patently Problematical”, The Economist, Sep 14, 2002.

Research supportive Regulations

The sectoral regulation of markets has a bearing on R&D activities, both directly and indirectly through the ability to market innovative products and services, notably the rules and practice of standardisation and of public procurement.

The de- or re- or just regulation of product and services markets should aim to favour competition and business development while securing a high level of protection for consumers and the environment, on a level playing field for enterprises. There are numerous cases where the imposition of safety or environmental constraints has created new market opportunities for high-tech products or processes, with long-term positive effects on growth and productivity, which prove far more important than the short-term negative effects of the new constraints.

Overly restrictive regulations prove harmful to business and R&D development. A striking example is the slower development of agro-biotechnologies in Europe due to stringent limitations imposed on R&D, while the sector was thriving elsewhere due to less restrictive regulation. An example of balanced regulation is the special treatment of orphan drugs in both US and EU law, providing incentives for spin-off firms to develop drugs for these small niche markets. The R&D stimulated by this legislation has also led to significant technology spill-overs in other areas of the biotechnology sector.

Standards policy play a critical role in the commercialisation of new technologies, as in the case of mobile telephony. Industry can determine its own technical solutions for standardisation which can often be used to underpin legislation later.

Public procurement related to public infrastructure is an important funding source for some industries in areas such as transport, communications and defence. EU governments tendency to request established technologies in their fragmented tendering procedures discourages innovation. Changes in these areas could have a substantial impact on increasing private R&D investment.

Possible policy areas for review with a view to developing proposals for action

- Exploring the possibilities of European and national regulations to encourage R&D and innovation.
- Effects of regulation on R&D and innovation, both directly and through marketing new products & services.
- Focused regulatory reviews?
- Encouraging systematic development of appropriate common European standards.
- Creation of technological platforms for stakeholders interested in the use of new technologies[75].
- Evolving towards innovation-friendly public procurement rules and practices.
- Improving participation of SMEs by modernising EU public procurement law.

Competitive environment and competition rules

A degree of competition is fundamental for the economy to achieve the optimum allocation of resources and the highest possible welfare. Competition in product markets is essential to ensure that companies innovate to differentiate. Competition policy has evolved from a formal approach to a more economic and effects-based approach. It takes into account the dynamic nature of markets and the specific characteristics of R&D

[75] Recent examples at European level include the proposal for the European and Developing Countries Clinical Trial Partnership, bringing together governments and industry for the development and testing of new medicines and vaccines against HIV/AIDS, malaria and tuberculosis. This initiative is based for the first time on article 169 of the EC Treaty.

and innovation. Three elements of Community competition policy have a bearing on firms' R&D: R&D co-operation agreements, technology transfer agreements and R&D State Aids.

R&D co-operation between firms is increasingly necessary to take advantage of economies of scale, sharing of knowledge and complementary technologies. Most co-operation agreements are not problematic for competition and benefit from exemptions under article 81 (3) of the Treaty relating to efficiency considerations. The new Block Exemption Regulation 2659/2000 on R&D agreements[76] reduces the regulatory burden for companies and gives them greater contractual freedom. With regard to technology licensing agreements, the current Block Exemption Regulation[77] will also be revised, following the same approach as for other Block Exemptions. The aim is a simpler and possibly wider block exemption for technology licensing agreements, limiting competition policy scrutiny of licensing agreements to situations where it is necessary, and providing greater legal certainty.

As for state aids to R&D, the Commission recognises their legitimacy in addressing market failures and their important role in the knowledge economy. In line with the requests of the European Councils of Lisbon and Stockholm, the Commission is also committed to encouraging the redirection of state aids towards horizontal objectives, including R&D. In the light of the Barcelona 3% objective, it has considered that the current Community Framework for State Aid for Research and Development, which allows for supportive R&D intensities, should be prolonged until at least 2005[78]. For the next revision of the Block Exemption Regulation for SMEs, the Commission will consider extending it to state aids for R&D.

In competition policy implementation, a permanent challenge is to understand future impact of changes in industrial R&D and innovation processes and to assess their effects on future market dynamics and competitive conditions, in particular in highly innovative industries. A dynamic view going beyond a static appraisal and more foresight is required.

Possible policy areas for review with a view to developing proposals for action

- Longer term competition policy decisions, taking account of market dynamics and competitive conditions in assessing R&D and innovation activities and their outcomes.
- Monitoring the re-orientation of State aid to R&D and its leveraging effect on investment.
- Pursuing studies on the adaptation of the Community Framework in the context of its next revision in 2005.

Supportive financial markets

Most companies require access to equity and/or debt financial markets for investment in R&D and innovation at some stage. High growth, high technology companies are critically dependent on access to equity financing at different stages of their development. Full implementation of the Financial Services Action Plan (FSAP) and the Risk Capital Action Plan (RCAP) is therefore important to create more efficient and integrated financial markets in Europe, thereby improving access to and reducing the cost of external finance. This is even more necessary given the recent severe downturn in market sentiment.

Large firms are able to access the European Investment Bank (EIB) loans to finance R&D and innovation activities. Properly designed debt instruments, such as bonds and securitised loans, could become a significant source of finance for mid-size firms and other organisations investing in R&D and innovation.

[76] OJ L 304 of 5.12.2000.
[77] Commission Regulation 240/96, OJ L 031, 9.12.1996.

Possible policy areas for review with a view to developing proposals for action

- In the context of the implementation and possible follow-up of the RCAP and the FSAP, identifying measures that would help foster debt and equity market financing of R&D and innovation in companies of different size at different stages of their development.
- Within EIB's "I2I"[79], financial instruments contributing to the objective.

Macro-economic stability and favourable fiscal conditions

Public policies in support of R&D should be considered in the context of the requirements to maintain a budgetary position "close to balance or in surplus" over the economic cycle. Fiscal discipline contributes to macro-economic stability and to the creation of a supportive environment for R&D and innovation. Sound public finances are beneficial to R&D investment in several ways. Low real interest rates reduce the cost of long-term investments in R&D. Price stability reduces uncertainty as to the rate of return for investors. This is especially helpful for R&D, where returns often only materialise sometimes, and usually in the medium to long term.

Efforts to enhance capital accumulation, including public support for R&D, must to a large extent come through restructuring of public expenditure[80]. This can mean a move away from direct funding of the public research base towards more indirect support, or more market oriented forces. A sound tax environment has positive effects on R&D and innovation. For enterprises operating across borders within the internal market, there is a need to create the appropriate direct tax environment so that decisions on investment in R&D are not distorted by purely tax-driven decisions. As PFI[81] methods are also becoming more popular, public research organisations have to start to understand these instruments better – not maybe to use them in the first order but certainly to understand how major sources of future finance may operate.

Possible policy areas for review with a view to developing proposals for action

- Exploring Member States reform of tax systems.
- Improve incentives to investment in R&D and innovation.

Public financing for Innovation

Public support to stimulate private R&D investment is justified if the private return is lower than the social return, or to address systemic failures[82]. Public authorities have a range of financing instruments at their disposal, each instrument has its own characteristics and merit depending on sectors and countries. More effective design and implementation of these instruments, individually and in combination, can contribute to the achievement of the 3% objective.

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78 Community Framework for State Aid for Research and Development, OJ 45, 17.2.1996.
79 Innovation 2000 Initiative, a programme of the EIB, www.eib.lu.
80 Report from the Commission and the (ECOFIN) Council to the European Council (Stockholm, 23-24 March 2001), "The contribution of public finances to growth and employment: improving quality and sustainability", Doc. 6997/01
81 Private Finance Initiatives, or PPI/PPF/PPP – Public Private Investments/Finance/Partnerships.
82 For example to enhance interactions between different parts of the research and innovation system.

Direct support measures

Direct support measures are particularly appropriate where governments want to retain control over the type of research carried out and orient research efforts towards public policy and long-term objectives. They are the predominant mechanism for promoting private investment in research. They should be directed to areas in which the private sector faces significant obstacles to investment. In this regard, public-private partnerships can play an important role in boosting private investment by reducing the risk. There is a wide range of direct support programmes in operation across the Member States aimed at collaboration between knowledge producers and users[83] in specific technological sectors, creating and developing science and technology parks and stimulating networking of private and public research units. Instruments include subsidies, competitive grants, procurement, grants repayable in case of successful commercial exploitation and block funding of public institutions. Many countries implement several types of scheme simultaneously.

Fiscal Incentives

Continuity in fiscal incentives encourage a flexible and responsive market allocation of R&D investment between competing technologies and sectors and entail less interference in the market. They allow faster reallocation of resources between technologies in response to the increasing pace of technological change and market developments. Enterprises know in advance the level of incentive available and so the true cost of research investment in advance.

Fiscal incentives for R&D of various types are increasingly used, with 18 OECD countries now employing them as against twelve in the mid-1990s[84]. Tax credits for R&D expenditures are becoming more popular than tax allowances. A number of countries either target R&D tax incentives to smaller firms or provide more generous provisions to these firms than to large enterprises. Some schemes are focused on wage costs and others are aimed at encouraging collaboration between industry and public research organisations. Member States must co-ordinate initiatives in this respect to avoid harmful tax practices developing.

Guarantee Mechanisms

Inadequate access to external debt or equity at reasonable cost is a common problem for companies, especially for newly established high-technology companies. It is more acute for R&D financing because of the risk involved. So guarantee mechanisms for both equity and loans can be attractive means of increasing the availability of capital and reducing access costs. Guarantees provide a means of sharing risk, thus reducing the exposure of borrowers/investors and companies. In general they can potentially exert leverage on private investment in R&D at a lower cost than direct or fiscal measures. Guarantee mechanisms vary depending on the type of company. For high technology start-ups, equity guarantees can stimulate investment by reducing the level of risk involved and increasing the rate of return. Loan guarantees are generally more appropriate for SMEs in traditional sectors because of their preference for debt financing. A variety of loan guarantee schemes are currently operated at Member State and European levels but these are not generally designed specifically for R&D.

[83] This concerns also the growing firms which have little or no R&D capability but outsource their R&D needs.
[84] European countries are Austria, Belgium, Denmark, France, Italy, Netherlands, Portugal, Spain, United Kingdom and Hungary. While a few countries have discontinued or are considering phasing out their tax incentives for R&D, more have enhanced them in recent years or are studying ways to do so.

Public supported Risk Capital

As the number of high technology companies grows, risk capital, which is their major source of capital in the seed, start-up and development stages, contributes increasingly to the financing of R&D. Despite recent growth in the supply of early stage funding, risk capital is still not playing as full a role in Europe as in the US. In seeking to close this gap, the public sector is playing a growing role at regional, national and European levels, especially through guarantee mechanisms and fiscal incentives, reimbursable grants, subsidised loans and direct equity investments in risk capital funds. Some schemes have recently started in a number of Member States to stimulate private investment in funds associated to incubators and science parks or dedicated to funding R&D in high technology start-ups.

The European Mezzanine Market[85]

Where will the investment come from that drives the expansion of capacity generates public and private rates of return? The mezzanine capital market is a useful proxy for investment confidence in the risk sector. Companies go there when they are reluctant to approach banks, and when risk is to high for market mechanisms. Therefore mezzanine finance is often intermediate term innovation oriented investment. The first half of the year 2002 saw a significant reduction in the levels of re-engineering of enterprise activity in both the UK and Continental Europe with the total value of all investments falling by 59% to 19bn Euro compared with 44bn Euro in the first half of the previous year.

Against this background the demand for mezzanine has been relatively stable. Private equity houses, who have been competing strongly for the relatively scarce quality companies, have been keen to have appropriate levels of leverage in their financing structure. The high yield bond market, because of its current volatility and unreliability, has not been as attractive a funding source as it has been in the past. This, together with the more cautious stance taken by some banks on senior debt lending, left good opportunities for mezzanine finance.

Although competition for mezzanine has increased from one or two of the newer independent funds, there continue to be relatively few banks who have a significant appetite for mezzanine. When there is the need for substantial amounts of mezzanine, debt arrangers are often nervous of taking on significant underwriting risk and mezzanine capital funds are often approached. This kind of finance will becomes more useful in the post-research, pre-market phase; as it is geared to performance and is short to medium term.

Mixing instruments

As no single instrument is able to provide the full range of incentives. It is important to ensure that different instruments are cost-effective and avoid possible crowding out effects, both in their individual features and in their interactions. The optimal mix of instruments will differ across countries and regions. Financing needs vary across industry segments and each segment contribute differently to the overall private investment in R&D. Furthermore, the optimal level of public spending on R&D and its allocation between industry and public research institutions also depends on the characteristics of a country's R&D system.

The use of consistent criteria for the design and impact evaluation of individual instruments and of the mix of instruments would facilitate policy making and mutual learning across countries. At Community level, several programmes and initiatives contribute to stimulate private investment in R&D through a variety of financial

[85] Extract from Annual Report by the Intermediate Capital Group, Oct 3rd, 2002.

instruments (grants, loans, equity, and guarantees)[86]. Increased complementarity and synergy between these instruments is being sought to ensure maximum overall impact[87].

Possible policy areas for review with a view to developing proposals for action

- Benchmarking research policies, taking into account differences in contexts.
- Identifying good practices and innovative schemes to enhance the leverage effect of the various public support instruments on private investment in R&D.
- Making more use at regional, national and EU levels of these instruments.
- Improving understanding of effective and appropriate mixtures of instruments.

R&D and innovation in corporate strategies and management

The place of R&D in a firms overall business strategy is the key to investment strategies. Firms which have integrated R&D and innovation in their business strategy tend to perform better and to invest more in R&D. Many firms, however, have not integrated R&D into their corporate strategy and are not making full use of productivity-enhancing R&D management methods and tools[88]. This also concerns medium and low-tech sectors, which are becoming more knowledge-intensive as firms in these sectors increasingly need to develop their capacity to acquire and absorb new technologies and knowledge.

The recognition of the growing importance of intellectual capital as a key asset of enterprises is also rising in significance. In annual reports, many firms refer to their R&D activities merely as a footnote to their accounts, expensing the entire sum in the current period; reducing significantly their visibility to investors.

Possible policy areas for review with a view to developing proposals for action

- Promoting awareness and the use of good R&D management practices.
- Promoting the accounting of intellectual capital within enterprises.
- Encouraging the reporting of R&D and intellectual property assets.

Implications for Public Research Capacity

There is little else but to recourse to the numbers game. The public sector employs a significant proportion of FTE R&D staff in the EU member States, much more so than in the US. The table below gives some absolute numbers.

[86] In addition to the Community Framework Programme for R&D, these include the “Innovation 2000 Initiative” of the EIB Group and the Structural Funds (normal programmes and the Innovative Actions). The guarantee and equity facilities of the Multiannual Programme for Enterprise and Entrepreneurship can also be used to finance R&D and innovation activities.

[87] The co-operation agreement between the Commission and the EIB in the field of R&D is aimed in particular at facilitating the complementary use of various instruments and taking better into account the specificities of R&D in the design of EIB instruments. The establishment of EIB loan facilities for financing of European strategic R&D projects, which is being considered to facilitate the financing of multi-partner projects, would also contribute to the development of synergies between the Framework Programme and EUREKA.

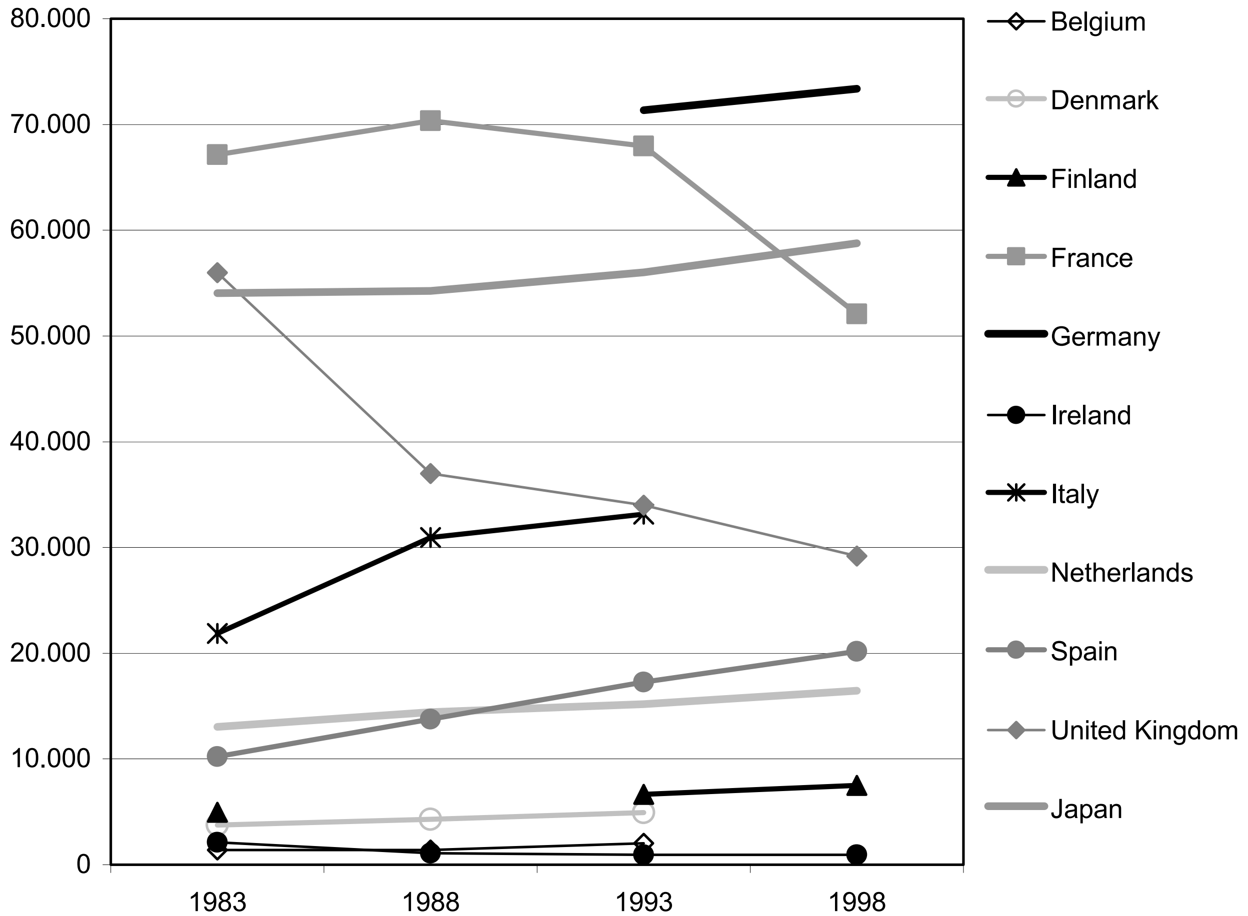
[88] It is expected that changes in industrial R&D processes and management will accelerate in the coming years, increasing the scope for improving R&D productivity through more extensive use of information and communication technologies (e.g. foresight, scanning, knowledge management, simulation and prototyping).

Table 1. Government total R&D Personnel (FTE)

	1983	1988	1993	1998
Austria			2.107	
Belgium	1.384	1.388	2.019	
Denmark	3.763	4.306	4.916	
Finland	4.957		6.655	7.498
France	67.142	70.341	67.958	52.082
Germany	49.944		71.363	73.369
Greece	3.688		4.828	
Ireland	2.126	1.079	927	941
Italy	21.871	30.947	33.164	
Luxembourg				
Netherlands	13.050	14.420	15.190	16.451
Portugal		4.114		
Spain	10.212	13.747	17.266	20.170
Sweden	3.313		3.289	
United Kingdom	56.000	37.000	34.000	29.197
EU	243.499		265.520	254.467
Japan	54.040	54.253	56.015	58.762

OECD MSTI Table 57. (NB: qualifications apply to certain values).

Figure 2: Government total R&D Personnel (FTE)



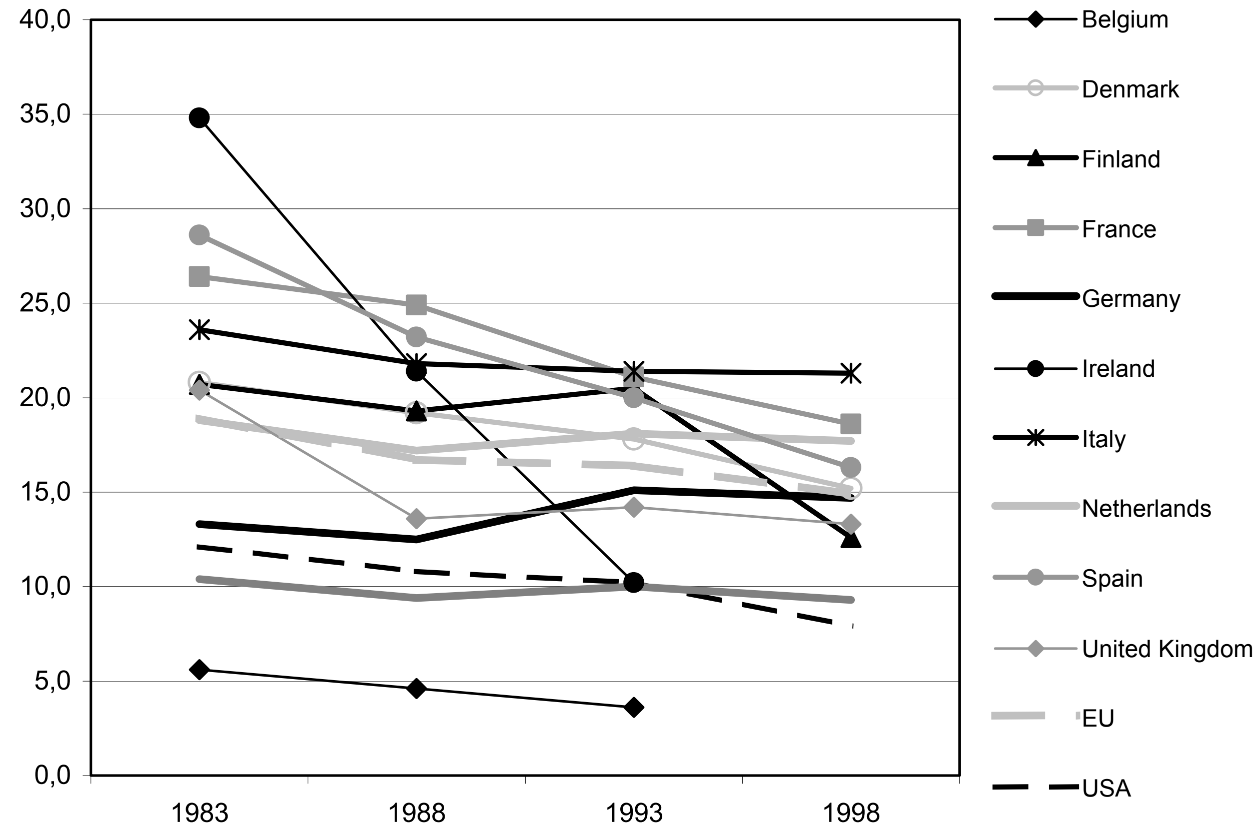
OECD MSTI Table 57 (NB: qualifications apply to certain values)

Table 2. Percentage of GERD performed by the Government sector (excludes HE)

	1983	1988	1993	1998
Austria			8,9	
Belgium	5,6	4,6	3,6	
Denmark	20,8	19,2	17,8	15,2
Finland	20,7	19,3	20,5	12,6
France	26,4	24,9	21,1	18,6
Germany	13,3	12,5	15,1	14,7
Greece		47,6	32,0	
Ireland	34,8	21,4	10,2	
Italy	23,6	21,8	21,4	21,3
Luxembourg				
Netherlands	18,8	17,2	18,1	17,7
Portugal		33,1		
Spain	28,6	23,2	20,0	16,3
Sweden	5,1		4,1	
United Kingdom	20,4	13,6	14,2	13,3
EU	18,9	16,7	16,4	14,9
USA	12,1	10,8	10,2	7,9
Japan	10,4	9,4	10,0	9,3

OECD MSTI Table 19
(NB qualifications apply to certain values)

Figure 3: Percentage of GERD performed by the Government sector (excludes HE)



OECD MSTI Table 19. (NB qualifications apply to certain values)

The one also has to review the levels of Government Funding relative to GDP (civilian sector only) and review their distance from the 3% target as well as their recent growth rate[89]

Table 3.

Country	Compound annual growth in GERD		Civil GERD as a percentage of GDP		Defence R&D as % of Govt. R&D outlays for comp.	
	1991	**1995**	**1991**	**1995**	**1991**	**1995**
Denmark	6.1	6.9	1.7	1.9	0.6	0.5
France	0.5	0.3	2.0	2.0	36.1	30.3
Germany	--	0.6	2.5	2.2	11.0	9.1
Hungary**	--	--	1.09	0.75	--	--
Iceland	18.8	12.0	1.2	1.5	0.0	0.0
Ireland	15.0	15.6	1.0	1.4	0.0	0.0
Italy	--	1.0	1.2	--	7.9	4.7
Norway	1.1	--	1.6	1.6	5.7	5.0
Portugal	11.6*	-1.0	0.6	0.6	0.8	1.3
Spain	5.1	2.7	0.8	--	16.8	10.4
Sweden	-0.9	--	2.7	--	27.3	20.9
UK	-5.1	-0.3	1.7	1.7	43.9	37.0

Source: OECD (1997), *Main Science and Technology Indicators,* No. 2, except Hungary.
*1992
** This data is illustrative only - to show the fall in GERD in the period. It is drawn from Hungarian statistics, which do not yet conform with OECD standards. In particular there is no breakdown between public and private Government expenditure.

Capacity Need

A VERY SIMPLE calculation below draws some alarming conclusions. Using the average annual compound growth rate for GERD and the average GERD rates as a % of GDP from the period 1991 through to 1995, then applying it to Government staffing levels for 1998, suggests a potential shortfall of over 300,000 staff, if the public sector is to keep pace with industry. The table below covers some of the EU MS to exemplify the trends.

Table 4.

Country	Av GERDGr	AvGERD%	Short 3%	%short/ GERD	TotGovStaff	Potential Shortfall
Denmark	6,5	1,800	1,200	66,7%	6.200	4.133
France	0,4	2,000	1,000	50,0%	53.000	26.500
Germany	0,6	2,350	0,650	27,7%	72.000	19.915
Hungary**	0,0	0,925	2,075	224,3%	8.200	18.395
Iceland	15,4	1,350	1,650	122,2%	650	794
Ireland	15,3	1,250	1,750	140,0%	880	1.232
Italy	1,0	1,100	1,900	172,7%	31.000	53.545
Norway	1,05	1,600	1,400	87,5%	4.800	4.200
Portugal	5,3	0,600	2,400	400,0%	5.900	23.600
Spain	3,9	0,400	2,600	650,0%	22.400	145.600
Sweden	-0,95	2,350	0,650	27,7%	3.200	885
UK	-2,7	1,700	1,300	76,5%	29.600	22.635

[89] Though the recent economic recession may reduce these growth rates considerably for the FY 2002-3.

True, industry is supposed to accelerate its investment relative to public increase by a margin of 2:1, but this still **suggest a potential shortfall of over 200,000 staff** in the public sector ahead of the 3% target. This compares to a 255,000 total employment roll for the EU15 MS in 1998[90].

Towards concerted European action

The challenge in this policy area is to mobilise the Member States to engage in a constructive dialogue to develop new incentives to raise the overall investment levels while avoiding negative impacts. If only 20% of the total economic benefit of innovation goes to investors, and the rest of the benefits spill over to society at large[91], then the public contribution can be respectively higher than it is currently, one can suggest. IPR reforms have to balance control vs. dissemination, innovative economies are good for overall economic performance only if there is an adequate flow of ideas and knowledge.

Public organisations will be somewhat less impacted as GovERD will be expected to rise less rapidly than BERD towards the summed 3% target. However, these factors are not independent.

Firstly, increased investment by industry will lead to greater demand for Human Resources which because of reward structures can be seen as incentives by younger researchers to steer towards industry and not the public sector. The public shortfall is likely to be sizeable in any event if the investment targets are approximated.

Secondly the trend in industry will be to invest in near-market areas, which is also the area where public laboratories are urged to steer towards often, increasing competitive pressures and leading to possible crowding out effects. At worst, the public sector takes the best, the public sector get the rest, as in Ireland[92]; or the exact reverse as in Portugal[93]. The balance is the key.

What could also happen is if government develops better indirect incentives to invest in R&D and enterprise remains reluctant to invest in the required infrastructure, then the public laboratories may be the unexpected beneficiaries of increased contract research.

Accession states not only have a huge gap to bridge, but also have relatively little experience in these policy domains (the exception is Hungary). It is necessary not only to improve the effectiveness of the European R&D and innovation system, but also to address the EU's under-investment in R&D. It will require joint efforts involving the European institutions, all Member States and the Candidate Countries, as well as the enterprise sector. A wide array of public policies must be mobilised in a coherent way to address both framework conditions and the public financing mechanisms for R&D and innovation.

As a first step, the Commission will engage in discussions on the basis of the present Communication with European institutions, Member States, regions and interested parties, notably industry. Inputs from these discussions will allow the Commission to propose orientations in the context of its synthesis report to the 2003 Spring European Council, leading to the mid-term review of the Lisbon goals in 2005.

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[90] OECD MSTI 2000-1 Table 56.

[91] The Economist, The Growth Machine, p82 May 18, 2002.

[92] EPOHITE Project, STRATA action of 5th FP, Country Reports, Biotech Policy Reviews for Ireland, J Senker, SPRU, Workshop 15th October 2002, Brussels, to be published.

[93] EPOHITE Project, STRATA action of 5th FP, Country Reports, Biotech Policy Reviews for Portugal, J Calvert, SPRU, Workshop 15th October 2002, Brussels, to be published.

5.3 CAPACITY BUILDING AND THE ECONOMICS OF R&D: TOWARDS THE DESIGN OF RELEVANT EUROPEAN POLICIES

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The opinions expressed and arguments employed are the responsibility of the author and do not necessarily represent those of the OECD

0 – Introduction

<u>The R&D gap</u>

In his presentation (this Workshop) Michael Rogers discussed the following figures to illustrate and characterise the so-called R&D gap between the EU and the US (Rogers, *Towards 3% GERD and impact on capacity building,* 2002):
In 2000, the European GERD = 1.9% of GDP while the US GERD = 2.7% of GDP. More than 80% of the R&D investment gap lies with funding levels of the business sector, so the most important policy target is an increase in the level of private sector funding. The gap has doubled in constant prices since 1994.

In terms of economic performance, labour productivity gains in Europe have slowed down while they accelerated in the US during the second half of the eighties. Moreover, trends on markets for high technologies show some European weaknesses in strategic fields, as compared with US and Japan.

<u>The Lisbon target is a good idea!</u>

Approaching 3% of GDP by 2010 seems, thus, to be an excellent policy target. There are now many macro- and micro econometric evidences showing a positive correlation between R&D and economic growth (see the survey by Griliches, *R&D and productivity: econometric results and measurement issues*, 1995). It is fair to recognise the extreme sensitivity of this kind of results to the choice of econometric methods and the quality of the data used. But, even though each of these studies seems fragile and open to criticism on many counts when taken on its own, the overall convergence of the results is quite convincing.

<u>But…how to proceed? How to increase research intensity?</u>

Now taking a decision (approaching 3%) does not say anything about the operationalization and implementation of such a policy target. In order to decide how to make it, a series of very complex questions need to be answered:

- Why is there a gap?

Given some assumptions about a minimum level of rationality exhibited by managers, we can argue that there is a gap because it does not pay so much to undertake R&D in Europe as compared with the US.

- Why does it not pay?

Here we have two solutions that determine entirely different kinds of policy actions: either the rewards are too weak or the research productivity is too low. These reasons for the R&D gap are different. It is thus extremely important to get some ideas about the main reasons before designing a policy plan.

- Have different policy instruments different impacts?

If we come to the point that the main reason of the gap deals with the fact that rewards are too weak, the policy issue is, thus, to increase the rewards, which in turn raises a new question: how to make it. What is the effectiveness of government support for commercial R&D (which is one way to increase rewards) and what is the effectiveness of a policy towards the reinforcement of the patent system (which is another way). Same kind of question appears if we come to the point that the main problem deals with a low level of research productivity.

Answering the questions above is a prerequisite for designing some generic policy orientations. Now Europe is a complex system both at the political level (countries, regions) and at the institutional levels (various kind of public sectors; specific boundaries between the public and the private sectors for each country; various degrees of effectiveness of the institutional infrastructure which is supposed to support innovation in each country; and so on). This is why another set of questions appear to be very critical:

- Has one EUR invested here more impact than one EUR invested there?

Where will one additional EUR have the most important impact: in Germany or in Portugal? In a government laboratory or in a high tech start up? In a research university or in corporate R&D?

- Do we have the correct set of institutions to support and exploit R&D (to fully realize the potential benefits of additional capacities in R&D)?

While the Lisbon target is a good objective in terms of capacity building, the “know how to build R&D capacity” is still very weak and vague. There is, thus, a danger just to continue the same kind of policy that was implemented in the past with not a great rate of success (hence the gap)!
Such a “know how” depends on robust knowledge about the specific circumstances of Europe (why is there a gap, where an additional EUR will have the most important impact) and the effectiveness of the various classes of policy instruments.

I - Theoretical framework and policy issues for building R&D capacities

The theoretical framework leads to some normative argument about the institutional system that can be relied upon to generate knowledge and maximise spill-over. The objective of this paper is to start from this framework to identify 5 critical dimensions of R&D capacities and to address policy issues for each of them. The message is that we still do not know many things about the effectiveness of policy actions in this field and there is a cruel lack of evidences and robust knowledge about the social effects of these policies.

We will successively address policy issues related to these 5 pillars of research ca jnhpacities: commercial R&D capacities, basic research capacities, strategic capacities, network capacities and revolutionary capacities.

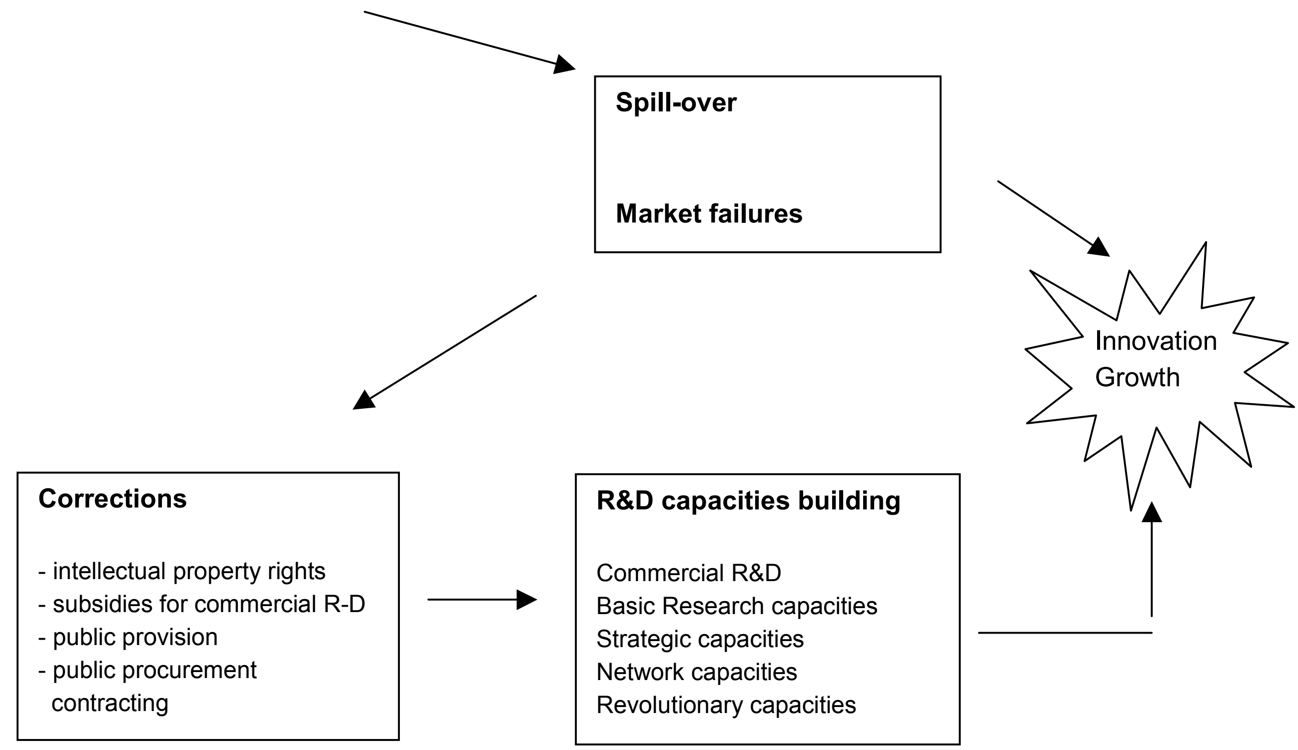
These various capacities may overlap. That means that they refer to different dimensions of an innovative capacity:

1. Commercial R&D capacities refer to R&D which is performed within the private sector (and may be publicly funded).
2. Basic research capacities refer to a particular stage of the innovation process and cover both public and private activities.
3. Strategic capacities deal with the ability to mobilise and concentrate resources under some centralised decision making processes to achieve a critical scientific or technological objectives (in US, the use of the expression “war against”.. cancer or communism is the appropriate expression to designate this kind

of co-ordination of activities towards a mission). This capacity is particularly dependent upon the effectiveness of the system of mission-oriented agencies and laboratories funded by the government.

4. Network capacities refer to any relation (university-industry, industry-industry, civil-military) that has the potential to maximise spill-overs between complementary resources,
5. Revolutionary capacities deals with the ability to shift resources out of areas of lower and into areas of higher productivity and greater yield. This is a kind of "meta-capacity" which covers the entire system of innovation. All actors are (or should be) involved in this kind of transition.

Knowledge as a public good



II - Policy puzzles for commercial R&D capacities: why are European countries doing less research than Japan and the U.S., and what would be the effect of more systematic R&D promotion policies at EU level?

We already mentioned the so-called R&D gap between R&D expenditures in the US, Japan and in EU, which is lagging behind. We observed above that 80% of the gap is due to lower funding by the business sector. This is apparently a simple problem but actually it appears as very complex when policy makers start to think about the kind of policy that should be designed to fill this gap. In fact, policy makers need to understand first why is there a gap. Different answers would lead to different policies.

<u>Two possible answers and the policy responses</u>

There are two possible reasons (Eaton, Gutierrez and Kortum, *European technology policy*, 1998):

- There is a problem with the rewards. It does not pay so much to undertake research in Europe because markets are fragmented, the IPR system is not effective, or subsidies to support commercial R&D are too low. If this kind of reasons is true; then the policy responses are straightforward: market integration, more effective and cheaper patent protection and more generous government subsidies will increase the rewards to innovative activity.

- Another possible explanation is that Europe is just not very good at doing research (low research productivity), either because it has fallen too far behind the technological frontier, or because it lacks the necessary research infrastructure e.g. an efficient and effective public sector). Here, the policy response is different: enhanced access to foreign technology and improved infrastructure would lead to an increase of research productivity.

It is thus crucial to understand the reasons. Econometric analysis (ibid.) show that the reasons are more related to the reward problem than to the productivity problem. With a few exceptions, European countries are not lacking in intrinsic capacity to do research or in research infrastructure, although Europe might suffer from a lower knowledge base. Actually, productivity of research in Europe is high. It is higher, for many countries, than in the U.S.

About the reward problem, Europe does indeed suffer relative to the US from having smaller and more fragmented markets for innovations. Increasing rewards to innovation seem, thus, to be the relevant policy target (market integration, patent system, government subsidies). In terms of various policies, the basic picture is that research in Europe is very responsive to various types of policies. Direct research subsidies have a substantial effect on research inputs, with an elasticity of about 4. Improved patent protection also raises research effort substantially.

These econometric evidences also show that an additional researcher in any of the European countries has more impact on overall EU production than an additional researcher in the US. Increasing research effort yields a payoff: less than 5% research subsidy raise average per capita income levels in the EU to a higher level of 10%. But the benefits are not contained only within the EU.

Finally, since the benefits of such research promotion policies are largely shared, only the largest European economies have much incentive to pursue them on their own. The rest have little incentive to engage in these policies unilaterally. This suggests a role for a co-ordinated technology policy in Europe.

These results show an unfulfilled research potential in Europe: The 3% principle is thus fully relevant from this point of view and there are economic opportunities to undertake policy actions oriented towards market integration, the improvement of the European patent system and the increase of R&D subsidies. The next step is to try to estimate the real social effect of these policies in building capacities.

<u>What is the effectiveness of government support for commercial R&D? We just do not know!!</u>

We know the theoretical justification of R&D subsidies (knowledge externalities create a market failure that leads to under-investment) but we still do not know whether public funding in fact manage to support R&D that would not have been financed privately. <u>Do these programmes truly work to expand R&D?.</u>

In a recent and provocative econometric study on the US SBIR (Small Business Innovation Research) Programme, S.Wallsten suggests that the federal funds spent in this framework have little effect on the amount of R&D the recipient firms conduct. (Wallsten, *The problem with picking winners: evaluating government support for commercial R&D*, 2001). Looking at data from 513 that applied for SBIR awards, Wallsten shows that SBIR awards appeared to crowd out private money that the company previously spent on R&D, such that each $ the companies received in government subsidies led to a $ 1 decrease in the companies' own investments. As a result, SBIR is not expanding the amount of research being done; it simply transfers the cost of commercial R&D to the government.

An effective government programme to stimulate innovation should encourage companies to continue undertaking R&D they would usually pursue out of commercial interests and support the companies to take an additional projects with a lower probability of commercial promise but that may lead to great gains for society. Such a programme would produce a net gain in the amount of R&D undertaken.

Programmes officers are happy if they can prove that the programme is picking winners. But the fact that some of those programmes are good in “picking winners” (that the funded projects achieve goals and succeed in the commercial markets) does not mean anything about whether the project needed a subsidy. Analysing the “picking winner” argument may just lead to the opposite conclusion: high commercial success rate (that policy makers like very much) may suggest that the programme is funding R&D that would have been undertaken in any case (without government support). The fact that commercial success rate slips (what policy makers do not like) could indicate that the agency is funding rightly higher-risk projects.

If government intends to support R&D that would not attract private funding, then government programmes should reject scientifically sound proposals that are likely to yield commercial successes; instead government should support proposals that promise great public benefit but would probably not receive private funding.

There is thus a need for policy experiments: one way to get robust knowledge on effectiveness is to randomise part of the award process (Jaffe, *Building program evaluation into the design of public research support programs*, 2000): some approved proposals would not be funded, and this is a way to determine whether these proposals ultimately attract funding from private sources; some rejected proposals would be funded, and this is a way to determine whether the proposals truly offer little return when brought to fruition. This is a kind of policy experiment which should lead to some evidences in order to answer to an important question: do public programmes finance projects on the margin or merely provide funding for projects that companies would have undertaken without federal support?.

Another, less radical kind of experiment is developed by Wallsten (ibid.): in any award process, there are winners and near-winners. Near-winners are proposals receiving quite similar scores as winners but are not subsidized (for budgetary reasons). This surplus of good projects is a good opportunity to evaluate the effectiveness of a policy. It is interesting to track the good projects that are not funded in addition to the winners. If the un-funded projects are ultimately less successful, then the programme is useful. If the un-funded projects are equally successful, subsidy appears as unnecessary.

<u>Additionality as a principle of European R&D funding</u>

Finally, filling the gap ad increasing R&D capacities are policy tasks to be undertaken at various policy levels (countries, Europe). This raises the issue of additionality as a principle of European funding. David et al. Have a devised a framework to identify the kind of objectives that meet the additionality principle and, thus, should guide the division of labour between the two levels (David, Genua and Steinmueller, *Additionality as a principle of European R&D funding*, 1995).

What the EU can do that results in gain relative to the actions of individual member states? The additionality principle is met when European funding is oriented towards:

- realising the advantages of economies of scale and scope through collective efforts;
- addressing externalities that span national boundaries;
- contributing to the development of EU (e.g. social cohesion);
- increasing the efficiency of national research efforts.

III - Policy puzzles for basic research capacities: towards new modes of organisations

Basic research needs to be developed here (in Europe) …

A policy argument, which attracted some attention in the 80s was that basic research is an international public good. Europe, thus, does not need to create and maintain its own capacity. The most cost-effective option is free-riding and the absorption of spill-over generated elsewhere.

However a series of stylised facts of the innovative process show that this argument is wrong and misleading:

- tacit knowledge: knowledge invented here is a temporary source of intellectual capital producing rents for those who have the know how (spill-over are not instantaneous);
- externalities are localized (spill-over are not a-spatial);
- absorptive capacity (spill-over are not free);
- thus, international free-riding is limited.

There is thus a need to promote and to develop basic research capacities. This raises various policy issues beyond the fact that additionality should here strongly guide the policy process.

Weak performance of the European private sector

The so-called European paradox deals with the fact that Europe is good in basic research and weak in technologies and applications. However, the tense "Europe is good in basic research" is a very vague statement and should not obscure the fundamental weakness of the private sector in terms of basic research.

	% du total global	% par le secteur privé
Informatique		
Etats Unis	43.6	22.0
UE – 15	25.4	11.1
Japon	6.5	46.6
Télécommunication		
Etats Unis	38.1	41.8
UE-15	20.3	34.1
Japon	12.4	78.8

Scientific publications in two fields of ICTs – 1997-2000.
Source: (Tijssen and van Wijk, *In search of the European paradox: an international comparison of Europe's scientific performance and knowledge flows in ICT research*, 2000).

Weak attractivity of most national systems

Highly regulated University systems in most countries just deprive them to access to the international pool of talents. In most European countries the supply of scientific skills is limited to the domestic pool. These systems are, thus, suffering, from very few entries against important exit towards the US system. Wit a few exceptions (UK, Switzerland), there are strong asymmetries with the U.S; and this offers a partial solution to higher education failure that this country is currently experiencing.

What is the appropriate distribution between national laboratories and research Universities?

The distinction between research universities and national laboratories is useful because incentive structures, modes of organisations and governance and general objectives are different.

In the former system, individuals are "free" to do the research they wish to (although the system of grants does determine a few main research thrusts). In return for financing, individuals and institutions must provide teaching. Modern scientists receive a fixed salary for their lecturing and related tasks, in addition to other rewards (e.g. promotion, reputation) for successful research. Thus, a vivid and excellent university research plays a great role to attract and train young scientists, to interact with the private sector and more broadly to communicate with society.

By contrast, in the latter system research is organized by the state in relation to strongly targeted objectives. Individuals are not "free" in the sense of the former system; they have to follow a certain research direction. It follows that they do not have to provide a service in return, such as lecturing, in order to create a fair balance of advantages and constraints. This system of mission-oriented agencies is a key instrument for the government when some large objectives need to be achieved (see below).

Thus, the question of the appropriate balance between the two parts of the public sector is an important issue. The idea of national laboratories sounds very attractive, particularly in a small country that sees them as a vehicle to achieve a critical mass by concentrating the nation’s best scientists in one place. However great reliance on national laboratories is detrimental to the growth of research universities and may have severe negative effects.

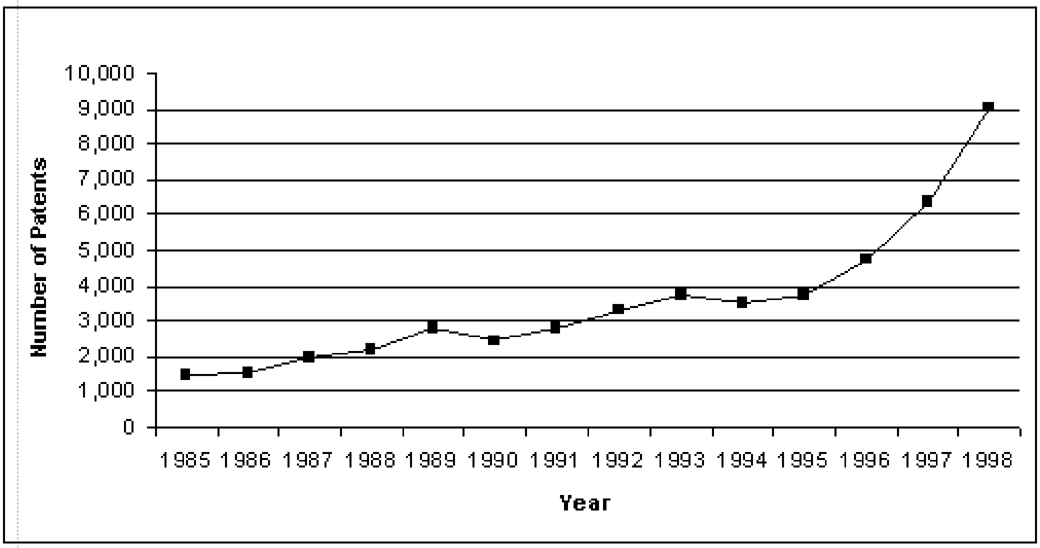
Do private markets for basic knowledge work properly?

The following table shows the patent upsurge phenomenon in upstream activities like biotechnology research.

The idea underlying a private market for basic knowledge and research tools is that firms patent their inventions and then sell licences to other researchers who develop products. But patents involve high social costs for the system, due to:

- monopoly on the exploitation of a research tool, the generic and cumulative value of which is thus lost. Social costs derive from the fact that exclusive licences and refusal to grant licences deprive the system of potential benefits generated when several firms with different capacities and perceptions of a problem are mobilized;
- increase in delays and costs involved in negotiation and litigation;
- possible blockages (anti-commons).

CHART 1 Number of patents



Source: BIO web page
[Source: U.S. Patent and Trademark Office, Technology Profile Report, Patent Examining Technology Center, Groups 1630-1650, Biotechnology 1/1977 — 1/1998, April 1999]

In most of research fields, "*creative discovery comes from unlikely journey through the information space*". If too many property rights are assigned to the micro-components of the information space, travelling through it proves to be extremely costly, even impossible, because at every time the traveller must negotiate and buy access rights.

On the other hand, the market has so many shortcomings in the area of basic research (uncertainty and difficulty in appropriating knowledge, despite the use of patents) that commercial success is rare. Anecdotal evidence and the relatively low stock market returns from research tool companies support this pessimistic view. This reflects what Nelson called "*the simple economics of basic research*". As argued by Cockburn (Cockburn, *O brave new industry, that has such patents in it! Reflections on the economics of genome patenting*, 2002): " *patents or no patents, capturing the value that ultimately derives from fundamental early stage research is extraordinarily difficult for profit-oriented organizations"*. In particular, the definition and observance of property rights on this basic knowledge are virtually impossible (Walsh et al., *The patenting of research tools and biomedical innovation*, 2000).

This conclusion suggests that the model of the small firm which invents a tool, patents it and hopes to obtain income by granting licences to other researchers who will pay only in case of success, functions only very rarely. Thus, the game is not worth the candle.

IV - Policy puzzle for strategic capacity: is it a good thing?

This capacity deals mainly with the system of mission-oriented agencies and public procurement. It is a key capacity to mobilise and concentrate resources on targeted scientific or technological objectives of (supra) national interest. A current example is the US national nano-technology initiative, which involves most of the governmental and federal agencies (NIST, DOD, DOE, NASA, NIH, NSF). A recent European example is the Galileo initiative.

Highly controversial capacity

Strategic capacity deals with a few large-scale projects, when there is a need for a high level of concentration of resources and centralization of decision-making. The monitoring of performance relies primarily on administrative processes. By minimizing the use of markets, this solution makes the greatest demand on administrative capabilities. Such a capacity has, therefore, been severely criticised by economists who like and believe in the power of market incentives: many problems of asymmetry of information make it difficult for research administrators to manage the activity. Moreover, the state replaces the market to select the "best"; government failures (instead of market failures) are likely to occur; such projects are high-risk ventures (a few large bets are placed on a small number of races); and, lastly, they create distortions in industrial competitiveness of the main industrial suppliers (Ergas, *A future for mission-oriented industrial policies?* 1988)

But history shows how critical are public programmes to create strategic orientations and to rapidly re-direct ressources towards a new objective

Whatever the reasons of the weakness of strategic capacities in Europe (*laissez faire* ideology, federalism, fragmented markets), this is a major handicap in periods of changes and uncertainty

V - Policy puzzles for the building of network capacities

Network capacities are a key element in R&D systems. Connectivity is the property of a system which allows it to maximise externalities and spillovers and to fully realise the potential for complementarities, synergies, recombination and static efficiency (economies of scale and scope). The more knowledge is distributed and used through various "connections", the greater innovative opportunities. There are many crucial connections but the most important are probably those linking or bridging I) universities 'research and industries' R&D, ii) industries and industries, and iii) civilian R&D and military R&D.

Networks are thus important as a component of R&D capacities. However, an emblem is not a rationale. The network metaphor is not the same thing as a well-worked- out economic model involving the provision of incentives and the design of co-ordination mechanisms to successfully support knowledge transfer (David, Foray and Steinmueller, *The research network and the new economics of science*, 1998).

University-industries

Direct transfers of knowledge between open science communities and the proprietary R&D organizations of the private business sector are especially problematic to institutionalize, because the co-existence of two reward systems within any single organization makes the behaviours of the participants difficult to anticipate, and tends to undermine the formation of coherent cultural norms which promote cooperation among team members. Incentives are different as well as the "mental mobilization", "the cognitive focus" which is on different aspects of a problem. Tensions are likely between academic researchers who are looking for hyper-innovative solutions and industry engineers who are focussing on reliability and cost-effectiveness.

Specially designed institutions -- having a research mission distinctive from that of either traditional academic science or profit oriented R&D labs -- may therefore be more effective in affecting such knowledge transfers.

Because it is a difficult problem, it is useful to partition it into three sub-problems:

- Inventions are developed in universities without any pre-allocation of those inventions to a private company. Important issues deals here with invention disclosure (incentives for university researchers), and the famous post-invention cost problem. Typically these costs are higher than pre-invention costs and firms would be unwilling to make this investment in development without some assurance of protection. This was, for instance, the rationale of the Bayh-Dole Act in the US. The Bayh-Dole Act provides a legal framework for patenting research results generated from publicly-funded programmes. It creates however several negative effects by restricting the diffusion of knowledge away from socially optimal level and by generating distortions in the other transfer mechanisms.

- The invention process is collectively undertaken and this collective learning process gives rise to complex organisational structures such as consortia and networks. The main policy issue here is to maintain a proper balance between the requirements of openness and autonomy of investigation (as these are required for the rapid growth of the stock of knowledge) on the one hand, and, on the other hand, the need for delays and restrictions upon the full disclosure of all new information (which facilitate the appropriation of economic returns that are needed to sustain investment expanding the knowledge base). Movements away initial conditions of institutional and organizational policies that have favoured either of the polar extremes (complete openness, or unrestricted proprietary control) can be expected to elicit an acceleration of the rate of industrially applicable scientific findings.

- R&D and technical services are provided by University research facilities. Policy issues deal here with the access of SMEs to these kinds of services (information provision, technical assistance, absorptive capacity, and so on).

<u>Industries-industries</u>

A great element of complexity in industrial systems relates to the evolution of products. New products are rarely stand-alone items; they are more often components of broader systems or structures. In modern technology, modularity is an objective that increasing numbers of firms are pursuing in order to benefit from the specialized division of labour and to create proper conditions for innovation. Module designers are free to try out a wide range of approaches as long as they obey the design rules ensuring that the models fit together. The definition of specifications for the interfaces and organization of integration are thus becoming an essential aspect of product development as well as providing opportunities for creating specific types of knowledge. A significant share of knowledge generation occurs in the process of interface design and system integration (Steinmueller, *Collaborative innovation, rationale, indicators and significance,* 2002).

It follows that the increasing importance of collaboration in knowledge production cannot be explained only by the usual rationales provided by the economics of research. To understand the rationale for these collaborations, it is important to create a dichotomy between:

- search model of knowledge generation (search within domains which are relatively unexplored or underexploited);
- coordination model of knowledge generation (design and integration) as a consequence of processes of modularization and integration.

Agreements broadly fall into these two categories according the outcome they are seeking.

Classic rationales have been thoroughly analysed in the literature. They concern: the need for sharing research costs and avoiding duplicative projects; the benefit to be harnessed from creating larger pools of knowledge, which in turn generate greater variances from which more promising avenues of research can be selected; and the economic gains to be generated from division of labour in research activities. Firms are spinning off significant discovery as new ventures. Those rationales still apply for the collaboration developed in the domain of basic research.

When integration is the issue, a possible rationale for collaboration concerns the need for reducing uncertainties and ambiguities in modular technologies and loosely coupled systems. This is a very usual rationale in sectors like automobiles, other transport technologies, and jet engines, for example. The traditional solution relied on vertical integration but this practice has now been revised in favour of outsourcing, requiring strong co-ordination mechanisms. The *Covisint* venture for instance, involving many car companies (DaimlerChrysler, Ford, GM, Renault, Nissan) supports co-operation in engineering and system design with a view to standardising parts, as well as supply chain management and procurement functions.

Another rationale for “integration-oriented collaboration” relates to the strategy of forming a tribe and building a coalition to create a standard.

More than ever, innovation and the production of knowledge require the assembling of knowledge bases, which are divided and dispersed. The transformations currently under way concern inter-organizational learning through increased co-production of skills. Such co-production – which may take various forms, from establishing a strong relationship between a supplier and a user to creating a complex set of co-producers based on the modularity of the product – significantly increases the requirements in terms of co-ordination, collaboration and knowledge management.

Dual technologies

The final critical connections deal with the coexistence of civilian and military R&D and manufacturing. The economics of dual technologies means the creation of proper conditions for economies of scale and economies of scope when objectives and functionalities are divergent between civilian and defence technologies. There are large economic opportunities for integration and spill-over between military and civilian research and manufacturing processes. However, those opportunities are not fully realised. It is useful to contract here the US proactive policy towards dual technologies versus European lack of policy.

The U.S. policy developments in this direction are indeed spectacular:

- reducing the use of military specification requirement for components;
- integrating military and commercial production (agile manufacturing processes);
- integrating generic R&D;
- insertion of commercial capabilities into military systems (military systems have to be designed for that purpose);
- active development of military technologies towards commercial application.
  (R.Guichard, *The dual policy under the Clinton administration*, 2000)

VI – Policy puzzles for the capacity to manage transitions

The final capacity deals with the large technological transition as a new technological-economic paradigm, (or general-purpose technology or technological system) is going to emerge, develop and spread over all activities of the economy and society. This is, thus, a capacity to shift resources out of areas of lower and into areas of higher productivity and greater yield. This capacity encapsulates all others capacities (commercial R&D, basic research, strategic initiatives and network capacities).

The difficulty in succeeding in such a transition is that the system has to deal with very different tasks, which are changing as the new technological system matures. Technological revolutions such as the harnessing of electricity, the emergence of the automobile and the advent of Internet tend to go through a series of predictable stages.

EXPERIMENTATION
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HYPER-COMPETITION

The management of the technological transition involves succeeding in these various stages (Varian, *Five habits of highly effective revolution*, 2001).

Lessons from Internet

How did the US system manage the Internet revolution is a very good illustration of this revolutionary capacity (Mowery and Simoe, *Is the Internet a US invention?* 2001). For each phase of the transition the US was successful in mobilizing particular ressources.

In the early stages of development (experimentation), federal R&D agencies, including military agencies and defence spending played a great role in creating an infrastructure of trained researchers and related institutions (*Funding a Revolution*, National Research Council, National Academy Press, Washington, 1999)

The role of federal agencies in the early stages is, thus, a critical aspect of the revolutionary capacity. Another case in point deals with the huge US DOD effort of funding biotechnology research projects (most of them having no military application!) (Feldman, *The role of DOD in building biotech expertise*, 1999).

As the technology matured, a different set of institutions became influential. The widespread adoption of Internet was encouraged by antitrust and telecom policies that weakened any emerging market power and facilitated the emergence of a domestic industry based on reselling local internet access at flat rate. Of equal importance was a long-established characteristic of the US economy: the large size of the market.

In a third phase, the rapid development of commercial content and business application was facilitated by the availability of capital (US venture capital industry) as well as the great tradition of entrepreneur-ship. The creation of new ventures is a key process but impeded by several problems (various types of disincentives to entrepreneur-ship (tax, regulation, bankrupt law); market size; cultural aspect; financial markets and venture capital).

Number of people starting up a company (as a % of the adult population)

High level	Medium	Low
USA, 8.4%	Italy, 3.4%	Germany, 2.2%
Canada, 6.8%	UK, 3.3%	Denmark, 2.0%
Israel, 5.4%		France, 1.8%
		Japan, 1.6%

In this process of creating new business, the emergence and development of clusters is an important issue. Clusters are not only a nice geographical agglomeration of resources and capabilities. This is above all an incentive mechanism creating in the same time intense competition among specialist producers with collaborative practices that blur the boundaries between local firms, and between firms and local educational and financial institutions.

Finally the phase of hyper-competition to create standards and control markets is characterized by the emergence of some American giants in the ICT industries.

VII – Conclusion

Capacity building is a complex process. It involves not only commercial R&D, but also basic research, strategic capacities, network capacities and revolutionary capacities. Each of those capacities raises particular policy issues. This is, thus, a serious challenge for Europe to address these issues. There is, therefore, an urgent need for generating robust evidences and scientific data about the effectiveness of the various policies, which are devised to build up, develop and maintain those capacities.

5.4 Challenges from the globalization: MNC networks and proximity arguments

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Introduction

Until the ‘90s multinational corporations used to invest only in their home countries, locating research laboratories close to their headquarters and concentrating research in their core areas. Since then though empirical evidence demonstrates new locational patters that are subject to research both in business economies and economic geography.

These changes are well corroborated by empirical evidence. Many countries and regions emerged as new net winners in the location of high value added multinational investments, while others are losing their initial strengths. Still others remain outside the main locational debate, as they did before corporate strategies changed. A major problem in reading these statistics is that while some individual countries and regions in Europe are improving their relative position and gaining in importance, the Union as a whole is further losing competitive advantage for R&D location compared not only to the US but also to emerging areas like China or other Asian destinations.

These recent tendencies not only affect economic performance but they constitute now a major input for the formulation of policies at all levels: regional, national and European.

The general pattern

In the ‘90s there is a tremendous increase in transnational research investments: multinationals become global. They install research facilities in locations that can offer interesting research potentials and establish close links with public research organisations that can demonstrate excellence in their core businesses.

Firms source research and innovation from multiple locations around the globe. Companies realize that for reasons of proximity that lead to economies of agglomeration competitive advantages are not at the national scale and clusters are locationally bound. So when major companies consider on new laboratory locations, they request highly skilled labour complementary competence in sufficient scale.

These two advantages are only offered massively in the US and major multinationals decide to locate their, even if sometimes the operational cost is three times as high as in corresponding European locations. So there is no surprise in that the US was the first country to attract R&D inward investment. In the year 2002 China has for the first time surpassed the US as the world’s most attractive investment and part of this investment is high tech. Equally Southern India has become very attractive for IT subcontracting.

From the point of view of companies there are mainly two rationales leading to strategies for outward R&D investments:

Picking brains, in the sense that global players with aggressive research strategies need and want to be present in all areas where there are potential breakthroughs, to assure that they will know of them on time, evaluate them and decide how they incorporate them into their current product mix and position themselves in new life cycles. This function is accomplished with local research subsidiaries and, in the case of less attractive areas from the research point of view, through specially designed employees in production-oriented subsidiaries, which now still have an antenna function (these individuals are called gatekeepers or “academic liaison officers” to correspond to the publicly sponsored “industrial liaison officers” of universities and public research organsiations).

Mutually-reinforcing benefits, in the sense that through accumulating effects, when investing in R&D in already strong areas multinational corporations benefit from the host country's competitive advantage but through their investments at the same time they contribute to its further reinforcement.

In addition to the pure form of R&D investments in host countries global strategies are even more characterised by a surge in the number and the extent of international cooperative agreements for joint exploitation of technological results and standards, as well as strategic alliances. Higher Educational Institutions and Research Establishments become more and more active parts of such networks and benefit in their capacity building by donations, cooperation agreements and longer-term licence obligations

In order to gain from technology transfers by host MNEs, (small) countries will first have to attract these investments. Although financial incentives will be helpful, they have to keep in mind that MNEs use long planning horizons. They are relatively footloose in the sense that the probability of ceasing foreign operations is higher. But especially if the 'mandate' of the foreign affiliate is broader, as measured by for instance its R&D-intensity, they tend to grow faster than indigenous firms. This is likely to be due to their access to, among other, international distribution channels, long-term capital and state-of-the-art knowledge of harder (manufacturing) and softer (organizational) knowledge systems. It has been found that (host) MNEs possess enduring advantages in adopting advanced manufacturing systems over indigenous firms. This means that technology spillovers are to domestic firms are limited. But it can also be used as an underpinning of promoting the outbound operations by indigenous enterprises, for upgrading their knowledge base (Knogg Report)

Empirical findings: Major trends in multinational R&D investments

Over the last decade or so, the dictates of globalisation have led many EU-owned firms with multi-national operations to locate R&D facilities in the US and elsewhere. There have also been flows into the EU, but net flows have been outward. Given the size of the firms involved and the associated levels of R&D expenditure, reversing this trend would have an appreciable impact on business R&D levels in the EU. It would also constitute an important ingredient of any attempt to reconfigure the industrial structure of the EU. However, the investment decisions of multi-nationals concerning the location of R&D facilities are driven by many factors, the most important of which tend to be proximity to key markets, the availability of skilled researchers and convenient access to knowledge infrastructures. Effective policies to stimulate relocation would necessarily have to target these framework conditions, most of which are the concern of broad economic or educational policy and lie outside or at the margins of firm-oriented R&D policy.

Firms with existing R&D capacity tend to increase expenditure on R&D only when there is a perceived need and when adequate resources are available to overcome any barriers to fulfilling this need. Appropriate policies to stimulate R&D expenditure thus often fall into two broad categories: those which help firms to recognise new opportunities and translate them into perceived needs; and those which help firms – small and large – to overcome any obstacles which stand in their way. Again many of these policies are those that deal with framework conditions such as the education and training of researchers and the resolution of human resource constraints, but others fall more directly under the heading of R&D policy. Foresight exercises, for example, can stimulate interest in new research areas, and awareness campaigns can also reorient research priorities. More directly, grants and loans for R&D projects help not only to recognise new opportunities but also help overcome financing barriers. More indirectly, R&D taxation incentives can accomplish the same job. Collaborative R&D programmes and similar measures also locate firms within a broader knowledge infrastructure and help overcome barriers related to restricted knowledge flows.

Policies to stimulate demand for the products of technological innovation and promote their diffusion constitute another category that can affect R&D levels. Enhanced market prospects affect perceived risk-reward ratios, lower entry barriers and make R&D more attractive, while resultant sales generate profits that can be ploughed back into R&D. Similarly, many measures designed to improve the commercialisation of R&D results and enhance the innovation performance of firms also have a subsequent, indirect but nevertheless positive impact on R&D levels (Shehan 2002).

It is not possible with existing data to say with precision how much of the growing gap in R&D intensities between the US and EU results from the activities of foreign affiliates of multinational enterprises. Multinationals account for much of the business R&D performed in the US, EU and Japan. In France, Germany and the US, foreign affiliates account for approximately 15% of business R&D (BERD), and in the UK they account for more than 30%. During the 1990s, R&D by US-based foreign affiliates of European firms grew at a much faster rate than either that of firms in Europe/EU (i.e., faster than growth in BERD in Europe/EU) or that of European-based affiliates of US firms. Between 1994 and 1998 (the years for which the most reliable, comparable data are available), R&D expenditures of U.S.-based affiliates of European/EU companies grew almost three times as fast as business R&D within Europe and the EU (14% annually versus 5% annually, see Table 2). At the same time, R&D spending in European based affiliates of US firms increased only 4.6% annually. Total R&D funding in US-affiliates of European firms increased 6.3 billion USD, compared to 1.6 billion USD for European affiliates of US firms. Total BERD in Europe increased 17.7 billion during this time period.

There is a strong sectoral component to foreign investments in US R&D. Over half of the approximately 7 billion USD increase in R&D by US affiliates (of *all* firms, not just European firms) was concentrated in just three industries: pharmaceuticals; radio, television, and telecommunications equipment; and finance, insurance and business services. Another 2.2 billion USD came from the motor vehicles sector.

Table 2. Comparison of R&D Expenditures in Europe, EU, and US-affiliates of European manufacturing firms, 1994 and 1998. Millions of current PPP USD

	1994	1998	Change	Annual increase (%)
BERD-EU	82,202	101,055	18,853	5.3%
BERD-Europe	77,043	94,764	17,721	5.3%
BERD-US	119,594	169,180	49,586	9.1%
Industry-financed GERD-EU	71,945	90,123	18,178	5.8%
Industry-financed GERD-Europe	65,646	81,818	16,172	5.7%
Industry-financed GERD-US	99,199	147,878	48,679	10.5%
R&D in US affiliates of European manufacturing firms[1]	8,980	15,315	6,335	14.3%
R&D in Japanese affiliates of EU manufacturing firms[2]	121	281	160	23.5%
R&D in EU affiliates of US manufacturing firms	7,426	8,902	1,476	4.6%
R&D in European affiliates of US manufacturing firms	7,569	9,154	1,585	4.9%

1. 1994 data refers to R&D funded by majority- and minority-owned affiliates; 1998 data refers to R&D performed by majority- and minority-owned affiliates.
2. Data refer to majority-owned affiliates only.
Source: Estimates data based on OECD MSTI database May 2002 and OECD AFA database, June 2002.

This whole section draws its evidence and remarks from Shehan (2002).

The European Round Table (ERT) points of view

The 42 ERT Member Companies account for a large share of private sector R&D investment in Europe, i.e. for more than 13% of total European R&D spending. Believing their collective views on the challenges and prospects for European R&D should offer useful guidance for policymakers, the ERT's Competitiveness Working Group has surveyed Member Companies with the aim of identifying the main drivers of R&D investment. This is a summary of their findings.

While, for obvious reasons, no company specific data can be shared outside ERT, the Survey revealed that, in 2001, ERT companies invested almost €37 billion in R&D in all parts of the world. The ratio of Global R&D to Global Added Value shows the importance of this activity for ERT companies, with the average ratio equivalent to approximately 9%, which can be compared to the 1.9% of R&D to GDP ratio. This, of course, encompasses a very wide variation between companies, not least according to the specific sector of activity, with the leading sectors being ICT and pharmaceuticals, followed by the automobile industry.

Of the Euro 37 billion invested in 2001 in R&D worldwide, the amount ERT companies invested in Europe was equal to 22.3 billion, which corresponds roughly to 13% of the Gross Expenditure on R&D in the EU as a whole. However, according to estimates put forward by the companies themselves, the amount they invest in Europe is not expected to increase much over the coming three years. A majority of companies intend either to maintain or to raise only slightly their current level of R&D spending in Europe. If this trend proves to be common to all companies and EU GDP continues to rise, then private EU R&D expenditure as a percentage of EU GDP will fall. This is significant given that, in order to attain the 3% objective set by the European Council in Barcelona, EU R&D effort must increase by more than 50% (from 1.9% to 3% of a rising GDP).

Moreover, despite a likely slowdown in the coming years, ERT companies still expect, on average, to increase their level of Global R&D expenditure, so in effect their increase will occur outside Europe. The reasons for this relate to the relatively unattractive framework conditions for investing in R&D in Europe, in terms of human resources and infrastructure, financial incentives and overall legislation and regulation.

Overall, the findings from the ERT Survey support the key messages of the Commission's recent Communication ("More Research for Europe" COM(2002)499). However, they point to a very sober conclusion: unless there is a dramatic reappraisal of Europe's approach to R&D and its framework conditions for business, the gap between the Barcelona target and the real world will not be bridged by 2010.

Anxious to play its part in closing this gap, the ERT has put together a set of recommendations aimed at dealing with R&D "black spots" identified by ERT Members as serious obstacles to achieving the EU's ambitions.

ERT's recommendations set out below with survey evidence in support, span human resources, financial, legal and regulatory policies:

- Invest in centres of excellence, raise the status and supply of scientists.
- Increase public spending to encourage more private R&D spending.
- Legislate better IPR and cut the red tape holding back new products and technologies.

What do we learn from case studies: market mechanisms and policy interventions

The areas that first attract multinational R&D investments are the agglomerations of high research potential: California, Massachusetts, Cambridge. They were market driven experiences with spectaculars results in growth rates due to the high social returns triggered by accumulated spillovers. But soon policy makers realised that these experiences could be replicated and facilitated through intervention. The Rhone Alpes region, Aachen, Louvain, Sophia Antipolis, Machester are only a few places to name, where the existence of (one or more) leading research organisations was supported by policy makers offering the necessary complementarities to attract MNCs. Even Ireland, being at the time a cohesion country with serious drawbacks succeeded through the combination of an effective human resources policy and a very persistent and high quality inward incentives management through the IDA to attract R&D facilities in the ‘90s, while in previous decades inward investment was only in assembly lines.

The crucial questions for MUSCIPOLI are: How can national, or regional capacity building be improved through foreign direct investments (FDI) active in R&D? Is there a role for policy makers?

The response seems to be positive: managing research capabilities and complementing them to achieve the necessary scale in particular disciplines is the best way to make a location attractive and market it. This is a long term undertaking, needs high budgetary resources and inspired policy managers and runs the risk of competition with other regions taking the same approach.

Conclusions and recommendations

The key issue for policy makers (European, national and regional) is how to make regions attractive for R&D investments of global players. The rules of the game are clear: R&D investments come only where interesting new knowledge can be found. While global firms do invest abroad for R&D now, they are only attracted by locations with a strong research base. They invest in other research-intensive countries or regions.There is a kind of virtuous circle, which acts also as a barrier to entry to new regions interested to apply the same policy.

The country level is very important for competition rules. The regional level is equally important for establishing effective mechanisms for social knowledge management, engage in learning and assure the existence of social capital.

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5.5 Conceptualising European Research Capacity

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This paper explores different ways of conceptualising European research capacity. It concentrates, in particular, on the relationship between so-called human capital, and the institutional settings a) in which Europeans do research, and b) in which European research is undertaken. I begin by describing a fairly conventional model in which research is undertaken within bounded and distinctive national research systems or within what amounts to a supra-national European system (incorporating distinctively European funders like the EU or the ESF). Much can be made of the relation between the European and the National levels of this model, and it is certainly possible to follow the circulation of people, ideas and resources in these largely institutional terms. However, detailed analysis of two EU programmes of social-environmental research suggests that descriptions of this kind fail to capture many of the dynamics at play.

Critically, researchers inhabit national and international research arenas at one and the same time. By paying attention to researchers' own strategies, we begin to see 'systems' in a different light. Deliberate efforts to build capacity or to steer European research agendas represent only part of the picture for it is also important to take note of the networks and relationships that researchers build between apparently separate programmes and initiatives. Developing these ideas I consider the relevance of thinking about European research systems as loosely coupled 'networks of networks'.

Analysis of a five-year ESF programme (TERM) provides some insight into the usually invisible routes through which such networks of networks evolve. As this case shows, institutional structures are of huge importance in shaping these processes and in building what we might describe as 'European' research capacity, but not in the way that programme managers and research policy makers expect.

These observations and ideas are of some significance for the design and development of deliberately 'European' research institutions and for the human capital that flows through them.

Chapter 6: Summary & Conclusion

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6.1 Introduction

The concluding chapter discusses the issues raised in the workshop and tries to put them in perspective on how they can be of value to policy makers, who manage science policy under uncertainty in such a complex era of transition: from stable to dynamic systems, from national to transnational/global policies.

A number of insights and ideas seem to have gained agreement. As the discussions proceeded it was clear that the major issues did not correspond to the headings of the sessions but were more broadly interacting with each other. So the structure of the conclusion does not follow exactly the sessions of the workshop but the thematic issues as they arose.

6.2 Definitions

R&D capacity building may be defined in various ways, of which the simplest is the accumulation of physical and human capital geared into research. Yet the mere existence of these two components alone does not automatically lead either into successful research (measured with research productivity indicators like publications, citations or patents) let alone into socially useful research (measured in the economic productivity of research results). Addressing shortages in the basic R&D components is thus only one aspect of the whole matter, their interaction and productivity is the real challenge. In that sense the more demanding definition of research capacity discussed in the workshop may be more appropriate, although it may also raise some objections, since it goes beyond research into technology and its commercial applications:

- Commercial R&D capacities refer to R&D, which is performed within the private sector (and may be publicly funded).
- Basic research capacities refer to a particular stage of the innovation process and cover both public and private activities.
- Strategic capacities deal with the ability to mobilise and concentrate resources under some centralised decision making processes to achieve a critical scientific or technological objectives (in US, the use of the expression "war against" cancer or communism is the appropriate expression to designate this kind of co-ordination of activities towards a mission). This capacity is particularly dependent upon the effectiveness of the system of mission-oriented agencies and laboratories funded by the government.
- Network capacities refer to any relation (university-industry, industry-industry, civil-military) that has the potential to maximise spill-overs between complementary resources.
- Revolutionary capacities deal with the ability to shift resources out of areas of lower and into areas of higher productivity and greater yield. This is a kind of "meta-capacity" which covers the entire system of innovation. All actors are (or should be) involved in this kind of transition.

6.3 Lessons and needs from member states

There is no doubt that each country follows its own path of development, which derives from or leads to its research capabilities. National systems of innovation are used in the literature to identify the role that research plays in this context. Grouping countries together to identify their common needs or success features leads to the study of different *country models*. Their characteristics, policies and path dependencies allow for lessons, which are possibly transferable to other countries.
The current economic debate and policy challenge in the member states of the European Union is the same: achieve sustainable growth without jeopardizing economic and social cohesion. The way theory suggests this can be done is through R&D and innovation. But despite rhetoric agreement member states present different historical patterns, variable efficiency and individual success or failure stories. The lessons drawn in this section are based on the papers from the first and last and a broad discussion mentioning distinctive features of individual countries. Each one of these groups of countries has important inherent characteristics, strengths and weaknesses, which offer lessons to imitate, to avoid or to think about.

The ***Scandinavian model***, which suggests that small, advanced, open economies can do very well in terms of successful R&D and persistent innovation was of major interest in this context. Yet, there is no common model in the Scandinavian countries. Finland and Sweden stands out as excellent examples based on the classic R&D indicators. They are outstanding if we look at the percentage of GDP spent on R&D. Finland is close to three percent while Sweden is close to 4 percent. But can we talk about a Nordic model? Yes and no! There are some likenesses, but also differences within the Nordic countries, and specially Denmark are in some respects quite far from the Finnish and Swedish model, and so is Norway the country traditionally included in Scandinavia.

Both these countries do not show the same patterns as Finland and Sweden. Denmark has been following an upward trend albeit at a lower level through the 1990's and recently reducing the upward curve while Norway measured in percentage of GDP is relatively stable below the other Nordic countries, so using these indicators we cannot talk about a Nordic model for building up European research capacity, unless we use other types of indicators than the economic ones.

The star among the Scandinavian countries is Finland, which managed to enhance research capacity in a very short period of time and restructure towards high tech. Finland is the country most often referred to as outstanding in the dynamics of building research capacity, so it is central to look for the explanation of the success. In the Finnish case it is argued that political consensus on science and technology policy means a lot. Political consensus, well functioning systems of planning, persistent R&D investment and IT infrastructure, emphasis on engineering education, as well as close cooperation between different actors and internationalization are contextual instruments of great importance that led to the Finnish success.

The big, rich countries differ among themselves substantially and cannot offer a generalized model. Their share in GERD/GDP, the role of industry or the defence sector, the patterns of cooperation vary. But their common element is the size of their market that allows to create research capacity in many areas and that makes an overall important contribution to the EU research capacity. But convergence requires that cohesion and accession countries, with lower GDP per capita than the EU average must catch-up to the rest. **For the other countries the convergence issue** must be carried into the European discussion on R&D: if research intensities converge this greatly facilitates the convergence in incomes. To put it in another way, unless research intensities converge the task of convergence in per capita income becomes harder to achieve. This is especially so if one also takes into account that countries (such as Greece and Portugal) that score low in R&D intensity also score relatively low on many of the other important determinants of competitiveness and growth: macroeconomic stability, human and social capital, functioning of product, labour and financial markets.

The opportunities to receive sufficient transfer funding to put their development process in motion combined with the emphasis put in the planning process on the need to build research capacity led to important lessons learned, like:

- Funding helps but it is not a sufficient condition,
- the need to increase hard and soft elements of the research system in parallel avoiding “easy” funding to flow to underutilized hard infrastructure,
- the immense role played by human resources,
- the need to reformulate management systems and institutions, which is very close to the lessons drawn from the accession countries’ experience.

Accession countries are in a different state than the current member states. They partly share concentration of resources in high tech areas and heavy industry with advanced countries but they also share a low level of exploitation with the cohesion countries. They posses high research capabilities in the academic sector but are deficient in exploitation structures, entrepreneurship and overall restructuring that would allow them to base their development in sustainable and innovative growth. Accession states R&D investment is progressing. They have an average R&D intensity of 0.7% of GDP, similar to the levels of Greece and Portugal, with the Czech Republic reaching 1.25% and Slovenia 1.5%. However, the share of business funding remains very low overall. Any impact on public sector capacity building is likely to be higher there.

CEECs have undergone a crucial transformation in their economic and political systems but the need remains to further increase their capacity in the area of modern science and technology and in innovation policy-making, to reformulate their policy-making process and also their way of thinking on economic, innovation and science policy matters. There are many layers of such capacities, which have to be reformulated in order to achieve the overall targets: the modernisation and internationalisation of these economies as a pre-requisite for improvement. The participation in the Framework Programmes has contributed to the improvement of physical and human capital and it is expected that through the accession these components will be further reinforced. But what seems to be of *high priority is the institutional building*. In this context the development and extended use of instruments like evaluation, foresight, technological assessment and indicators constitutes a key priority.

In the context of geographically located lessons there is an emerging need to take *the role of the regions* into consideration. The progressive build-up of the knowledge based economy in Europe calls for increased efforts for building capacity for research, technological development and innovation in the European regions (sub-national entities). This is especially true not only in the less developed regions (better known as Objective 1 regions following the jargon of the Community Structural Funds) of the European Union (EU) but also in those areas going through profound economic restructuring (Objective 2).

Efforts to reach this goal have focused traditionally in providing and improving relevant infrastructure (university and laboratory space and equipment; improved communication facilities (transport infrastructure and telecommunications)) and energy provision. Today it is firmly believed that this policy, while necessary in the early stages of a process for building up capacity, is not sufficient and ultimately not sustainable if it is not coupled by a strategy that focuses on building technological and innovation capacity in a region in dynamic terms. EU past experience with both approaches (Structural Funds and the RTD Framework Programme via the RIS / RITTS/ RIS+ initiatives) makes it a world leader in supporting the knowledge based economy in the regions. The Innovative Actions are directed into this approach and it is important for regions to take advantage of this opportunity.

A key conclusion in the discussion was that grouping countries to speak of generally well functioning models risks to lead to oversimplifications. Finland, Ireland and Germany are the countries that seem to have been improving their innovative performance and they definitely belong to different groups of countries. So it is specific features one should study more than country models.

6.4. Key components of research capacity

6.4.1 From human capital to intellectual capital
For individual policy makers it is more important to combine them and there are three relevant axes and ways as to how policy makers approach capacity building:

- physical research infrastructure (research equipment, building and other facilities),
- human capital (researchers, technicians and an overall attractive level of the workforce) and
- institutional building (legal frameworks, support mechanisms and environment conducive to innovation).

There is agreement that "advance was dependent upon the number of talented individuals who select science as a career." The ***human capital element*** of European research capacity can be defined in one of three ways, ranging from a broad definition including all European researchers to a narrow definition including only the researchers involved in integrated European projects:

- Sum of all researchers in Europe, adding all types, independent of their research activity, field or whether they are public or private or
- Sum of nationally based researchers involved in one way or another in research cooperation with a limited number of European researchers outside their own country (the partly involved European researchers) or
- Integrated network of European researchers involving researchers from several or all European countries.

Comparing Europe with the US in terms of researchers per 1000 workforce, United States has a larger proportion (8.08 versus 5.28 per 1000 workforce. But again the performance is not even among member states: Finland is outstanding with a proportion of 10.62 %, In addition in Finland Doctoral degrees have tripled since 1990: from 490 to 1 203 in 2001. Sweden is following the overall performance closely with 8.44 researchers per 1000 workforce. Countries like Ireland and Portugal are low in these figures but demonstrate a remarkable growth over the last years. But there is a slow growth rate of R&D personnel in some central European countries such as Germany, France, and especially Italy. However, average growth rate must be read with great caution, as countries start from very different level. At any rate if R&D investments are to increase they also demand a considerable amount of "knowledge workers". Hence, a strong focus is now directed at the efficiency of European higher education to increase its production and quality of PhD students. The currently observed shortage of scientists will eventually cause a gradual decline in the average ability of those entering science.

The scarcity of researchers in the case of Europe seems much more dependent upon social and political wills for organisational reforms of the higher education system so that young and bright people can pursue a scientific career without considerations of class, gender, and ethnic origins. The scarcity argument seems much less dependent upon the exhaustion of natural intelligence pools. If these pools are not sufficiently exploited – by means of social and political reforms – there will be a scarcity of researchers in Europe in comparison with United States and Japan. The Nordic countries have taken the lead, and as shown in recent statistics these countries can well compete and even outperform bigger and wealthier countries. The social welfare system pays off also with regard to R&D performance.

Given the above, what is of interest to policy makers is how to increase the number of researchers. Thus one needs to increase the total pool of engineers and scientists, from which researchers can emerge, but also to make research careers more attractive so that more people select research as a profession. In order to increase the pool of talented scientists, the crucial mechanism is educational reform. When more universities are created in a country, competition increases, and talented youth are at the same time offered richer opportunities. Hence, the pool of talents expands and intensifies; a motivational structure of high performance is the result. In addition the increase in production of doctoral degrees is most likely an effect of a highly de-centralised higher education system with full regional coverage. Such a decentralised system also demands that the pool of talented youth be expanded to include also that of women.

On the other hand highly regulated University systems in most countries just deprive them to access to the international pool of talents. In most European countries the supply of scientific skills is limited to the domestic pool. These systems are, thus, suffering, from very few entries against important exit towards the US system. With a few exceptions (UK, Switzerland), there are strong asymmetries with the U.S; and this offers a partial solution to higher education failure that this country is currently experiencing. This point is relevant both for the ERA, which needs to address intra-European mobility of scientists in general and researchers in particular, but also for the overall migration policies: European research policies need to make it clear to migration authorities that extra-European talents should be encouraged to enter the Union.
In addition to the pool of scientists and numbers of researchers it is important to recognize that for effective research one has to go beyond human capital and address the issue of intellectual capital. All available and necessary internal and external knowledge – preferably codified - has to be bundled in order to define product attributes and functionalities in line with the market. Knowledge is used in this process, in the product and as product. Therefore the strategic relevance of Intellectual Capital and its evaluation is considerable in product development. To better understand Intellectual Capital one needs to study it in its following components:

Human Capital reflects the ability and capability of company employees to react to market demands and apply solutions to customer needs. Thus the Human Capital comprises competencies such as skills, expertise and talents but also attitudes like leadership and management issues as well.

Organisational Capital reflects the capabilities of the organisation to provide products and services to the market. In a sense it comprises the environmental variables enabling the exploitation/maximum productivity of human potential. Therefore the Organisational Capital refers to processes, infrastructure, culture and relationships and management issues.

Market Capital comprises the strengths and the capabilities of the company in terms of the stakeholders, respectively the customers and the suppliers. On the one hand it comprises the capability of the organisation to recognise market demands in advance, which means to launch new products and services at the right time with the right features. On the other hand it comprises the interactive capabilities with the external interfaces. Therefore Market Capital contains all market related competence, customer issues, supplier issues and relationship issues.

Innovation Capital refers to the capabilities of an organisation to generate value in the future. This comprises the capability of an organisation to continuously improve and develop the potentials of the entire organisation. It contains therefore all the components in the development of processes, products and services along with technology and management issues.

The key issue is that al these forms of capital are underpinned by human resources, by capacity to do research and to develop and use knowledge brought in, generated and exchanged within a laboratory. Whereas laboratories without walls are feasible, without people is not!

6.4.2 Scientific equipment: a virtuous circle and difficulties to entry

Capacity building needs to address the issue of scientific equipment. There is a virtuous circle in the sense that good scientists go to places where they can find the most performing equipment to support their research, whereas the places, which dispose of good equipment and researchers demonstrate the highest scientific productivity (measured in publications, citations and patents per researcher) and are thus eligible (by per review standards in the public sector or income generation in the private sector) for increased funding and new equipment when new vintages appear in the market.

It is acknowledged that the competitive position of a nation's science base depends on access to scientific research equipment, which is sufficiently technically advanced to enable scientists to carry out the experiments required to keep up with the leading edge of research. Such equipment must also be maintained in good working order, and provided in an institutional setting that allows researchers to make full use of it. Scientific instruments may be usefully regarded as the capital goods of the scientific research industry. Therefore the conduct of scientific research generally requires some antecedent investment in specific equipment for purposes of enhancing the ability to observe and measure specific categories of national phenomena.

Continuing progress in science demands ever-higher performance standards from those who wish to remain at the 'leading-edge'. Evidence suggests that the cost of meeting the performance level demanded at the scientific leading edge has grown at a faster pace than costs have been reduced through technological innovation, leading to a positive 'sophistication factor' for scientific research equipment. The capital intensiveness of science has also increased through the growing number of fields requiring advanced equipment, notably the life sciences. For these reasons, research equipment has become a major science policy issue for many countries. It goes without saying that there are differences in the research intensity by sector (social sciences and humanities having considerably lower needs) and as a consequence countries and regions depending on their ambitions and sectoral specialisation.

Besides, the issue that is of interest to policy makers does not refer to scientific equipment for the private sector. In general their decisions are taken after meticulous return-on-investment calculations and are thus subject to the whole process of corporate technology management. In addition the most recent patterns demonstrate that for highly uncertain basic research big companies prefer to enter into partnerships with highly performing public research establishments, which dispose of the necessary equipment or outsource smaller research project to contract research companies. Major multinationals, like Nokia or Glaxo position now their new research facilities in regions, where they agree on major shared investments with company labs developing in parallel with major public labs. Continuing progress in science demands ever-higher performance standards from those universities who wish to remain at the 'leading-edge', increase their scientific productivity and attract funding and collaboration opportunities from industry. Also the competitive position of a nation's science base is affected by sufficient access to scientific research equipment for scientific researchers. Thus, it becomes important for policy makers to study the mechanisms for selecting, financing and managing expensive research equipment.

Evidence from the NSF (National Science Foundation) in the US shows that although Federal Government plays a diminishing role in supporting academic research, it still provides close to 60% of the financial resources. Fewer US institutions receive these funds. Research performing universities have increased their own funds, which now account for one-fifth of the total. Industry support has grown, but less than might be surmised given the close relationship between R&D and industrial innovation (NSF website, 2002). Europe seems to follow a different pattern with high fragmentation not only across European member states but even within them.

Amongst the strongest arguments presented in the workshop, based on a comparative study; was that funding of leading edge UK research groups should be less piecemeal and uncertain. Consistency and constancy of support are vital to nurturing high quality research. Also human resources and equipment acquisition are intimately interlinked but this is barely acknowledged in the context of present funding systems.

When managing research equipment purchases it is important also to differentiate:

- having a more strategic approach to the funding of research infrastructure in this cost range or simplifying the tendering requirements which may not be appropriate for the purchase of such expensive and sophisticated items.
- the research equipment itself is only one component of a package. A major item of research equipment will typically require several ‘complementary assets’ including refurbished or purpose-built accommodation, skilled technical and user support staff, preparation and analysis facilities and the more generic, supporting equipment required to go with them. In essence the question is one of providing a service package which offers adequate and appropriately supported opportunities to use equipment which is maintained in excellent working order, even when it has to be recallibrated to meet the needs of a mixed group of users. It would seem that the barriers to providing such a service package exist both in the UK and the US, though the greater variety of federal, state and private funding options available for basic research in US universities may provide some cushioning within the US system.

The potential for encouraging industrial use of academic research equipment, perhaps as a means of defraying the high costs of purchase or upkeep, would also seem to be fairly limited. Concerns about crowding out the leading-edge basic research for which the equipment item was funded in the first place, along with worries about subsidising commercial research with taxpayers’ money (or undercutting commercial services with taxpayers’ money) seem to outweigh any incentive to generate extra income. Indeed the simplest and most effective way for industrial researchers to gain access to university research equipment is by collaborating with academic researchers.

6.4.3 Networking and institutional building

Next to the complementarity of human and physical capital there is an issue for policy making on the type of actors to support. In addition all recent evidence suggests that it is not individual actors but the synergies that emerge from their interaction that produces the best research outcome. So a brief discussion of actors and their networking leads to interesting results.

Business enterprises are the major actors in the process of capacity building. The research potential of an organisation plays a major role in determining its development, its influences, the creation and distribution of wealth and the securing of competitive advantages in the ever-changing international economic environment. By focusing on research, EU firms can succeed in increasing productivity and consequently in achieving more rapid economic and social convergence. The economy of knowledge also requires greater willingness to embark on innovative actions, which are characterised by high risk, as well as special emphasis on the role that can be played by SMEs. The business sector, based on the big companies approach, mainly needs an improvement of framework conditions, i.e. macroeconomic stability, financial conditions, bankruptcy laws and IPRs. SMEs for their part are more interested in grants and venture capital schemes.

A significant number of SMEs are characterised by a particularly weak R&D potential. A portion of those companies appears not to have an adequate base of knowledge and resources in order for it to interact effectively with universities and research organisations. It has been proved that intermediary organisations, including the consultants, can fill in the above gap by encouraging the companies to maximise the benefit from knowledge coming from universities and to effectively incorporate the results of this knowledge in their business strategies.

The businesses are now invited to promptly search for and take advantage of all contemporary opportunities to develop new procedures, products and services, by allocating more resources to research and development (increase of R&D expenses of the corresponding international levels) and upgrading their existing productive infrastructures. At the same time, the businesses are obliged to acknowledge the leading part of technology today (through the achievement of results, it has been elevated to the position of the main strategic factor in the formation of company policy) and to merge their technological and business strategies.

Moreover and in order to make full use of the new knowledge, firms are obliged to have an adequate absorption capacity. The above need, combined with the necessary reformation of the organisational framework, renders the attraction and retention of human capital strategically important. Today, companies are obliged to supply more resources for the complete education and training of their existing personnel. Research and development is not only a generator of innovations, but also a producer of skills and qualifications. The usual practice of the leading companies in the world which search for specialised employees throughout the world, is ongoing in-house promotion - upgrading of their executives, through the appropriate in-house training, regular job rotating, as well as the granting of high salaries and suitable working conditions. In the process of maximisation of investment resources and research products or services, the development of interdepartmental working groups is also considered to be the most effective best practice.

Universities and research institutes, as the main entities which supply knowledge are actually in the current model of development asked to play a double role: one the one hand train new scientists and increase the pool of knowledge and, at the same time, attract collaboration with enterprises for innovative products but also elaborate and develop the new issues raised by the industry concerning the training of scientists and technologists, in order to equip their graduates with the necessary qualifications for contemporary labour markets.

But while business and academia follow their own agendas success models demonstrate that more than ever before there is a need for ***university-industry collaboration***. Analytically explained through tacit knowledge exchange or network externalities, this US-originated concept is gaining attention in Europe. Today more than any other time, the universities are invited to co-operate with businesses and applied research and alter their culture and orientation. A closer co-operation with businesses entails new sources of funding for the universities, new areas for the development of research in specialised scientific fields, as well as real opportunities for the optimum absorption of their graduates in the labour market. Besides, it is a fact that the prestige and acknowledgement of contemporary universities comes not only from their traditional theoretical applications, but also from their standard in terms of their contribution to innovative research.

Research institutes and in particular government research institutions (universities and government laboratories) and the industry are obliged to determine, in practice, how they will upgrade their co-operation. The ability of these institutions to develop services, which truly contribute to the successful commercial transfer of knowledge, demands the effacement of the strict and bureaucratic rules and procedures. Also, the development of personnel mobility between government research institutions and the industry, as a practice of vital importance for the promotion of research and innovation, requires the development of new policies for employment and human resource management in order to deal with the existing problems.

The excellence and scale of Europe's science base, including long-term research, are critical for the dynamics of the knowledge-based economy. Poles of scientific excellence around public research institutions tend to have a powerful leverage effect on R&D investment by all kinds of enterprises in the area, including enterprises, which would otherwise not invest in R&D. Regional authorities are playing an increasing role in attracting R&D related investment from abroad in this context. Facilitating mobility of researchers between public research and the private sector is also an important means of improving networking between public and private R&D in the EU. Start-ups from academia, although often slow to come to profit, are another important way of creating this link.

Direct transfers of knowledge between open science communities and the proprietary R&D organizations of the private business sector are especially problematic to institutionalise, because the co-existence of two reward systems within any single organization makes the behaviours of the participants difficult to anticipate, and tends to undermine the formation of coherent cultural norms which promote cooperation among team members. Incentives are different as well as the “mental mobilization”, “the cognitive focus” which is on different aspects of a problem. Tensions are likely between academic researchers who are looking for hyper-innovative solutions and industry engineers who are focussing on reliability and cost-effectiveness. Specially designed institutions -- having a research mission distinctive from that of either traditional academic science or profit oriented R&D labs -- may therefore be more effective in affecting such knowledge transfers.

The discussion on actor should not be finalised before taking a look into the role of ***Foundations.*** They are drawing upon private and/or public funds, provide an important source of research support in European countries. Often foundations have had an innovating effect on research agenda and capacity-building by acting as vehicles through which researchers can explore new research ideas and directions. Foundations will occupy a significant, and independent, space within the forthcoming European Research Area as alternative sources of research funding. Competing sources for research funding are essential for the health of science and scientific disciplines. Foundations should continue to seek to be “one step ahead” through keeping their agenda open to new researcher-led initiatives that explore new directions and new capacities to address societal challenges.

It is dependent largely on its financing via membership contributions from these public bodies and their “a la carte” funding of specific research programmes and other research activities that interest them. Its name as a foundation, therefore, is rather a misnomer because it is not in receipt of any endowment funds from a private benefactor. This makes its role and functions somewhat different to private foundations as such.

The case of the ESF was illustrated in the workshop. Over the years it has identified and developed scientific activities that are attractive enough to member organisations to make them invest “a la carte” in ESF beyond the level of their compulsory membership dues. In doing so, the ESF has performed a kind of “outreach function” for research councils, extending their European cooperation beyond traditional mechanisms such as bi-lateral agreements. The relative small beginnings of the ESF from 1974, in terms of its limited budget, also led it to experiment early with new mechanisms for research funding which maximised its resources. After establishing its membership base and organisational structure, from the early 1980s it began to experiment with a modest scientific network scheme and to develop the European Research Conferences (as a European counterpart to the US Gordon Conferences) in the late 1980s, both of these mechanisms were subsequently taken further in the context of the European Commission Third Research Framework Programme. In the early 1990s exploratory workshop schemes were launched on a competitive basis to provide “seed money” particularly to young researchers to establish and consolidate professional contacts on the European level for networking and project development purposes. These new mechanisms both combined with and strengthened “a la carte” scientific programmes through the input of new ideas and new research collaborations.

Research capacity building initiatives at ESF can be most usefully examined through the operation of four conceptual approaches of **“***Flexibility”, “Interdisciplinarity”, “Risk-taking” and “Think tank”* function**.** Working examples are drawn below from ESF

6.5 Aggregation into a European dimension: changes and new challenges

The key actor for research capacity are multinational enterprises (MNCs) in their trade and foreign direct investment activities, as well as organizations of international governance like the EU, the WTO and to a lesser extent the World Bank. Dealing with European research capacity building it is important to look in detail into:

- MNCs, their decision making process in the location of R&D labs and their strategic alliances;
- The decisions at the supranational level affecting research, namely the Lisbon and Barcelona targets of the European summit and their effects on the national and regional level.

6.5.1 Positioning Europe in the global context

Globalisation is strongly influencing capacity building both as a result of the market mechanism and as policy intervention. Pressures from international trade oblige big and small companies to become more innovative if they are to keep their market shares in Europe. Research capacity, as a component that strengthens SMEs was already discussed in the previous chapter.

In this process of globalisation MNCs play their own role in capacity building. They are themselves in a process of transformation. While in their traditional model MNCs were concentrating high value added activities, notably central management and research, in the developed home country and transferred production or assembly in the cheap-labour environments of the developing world, trends are now rapidly changing: Foreign markets, both developed and emerging ones, are not only considered as providers of market opportunities and cheap inputs but also as potential sources of new ideas. Thus the most dynamic MNCs develop a culture of international knowledge base through the establishment of research laboratories outside their home country but also through the creation of strategic alliances with companies with complementary activities or even competitors plus alliances with leading universities and research centers. Foreign laboratories can both play the role of exploitation of local assets or act as antennas that transfer in real time new knowledge. Even in subsidiaries without research activities there are individuals entrusted with the function of identifying interesting technological information and pass it to their headquarters (these functions are entrusted to “gatekeepers” or in some cases what is called “academic liaison officers” to paraphrase the “industrial liaison officers” function in academia).

Same as with the strong laboratories and the virtuous circle they create (which excludes other laboratories from the race for excellence) regions also find themselves in this position. MNCs, which are the strong private actors in research capacity building concentrate their overseas activities to regions, which can already offer state-of-the-art knowledge. They expect to find there both highly skilled personnel for their own programmes but also effectively subcontract research to highly performing teams. Originally this led to a concentration of MNC research capacities in the market-led excellence areas of Massachusetts and California in the US, plus to a lesser extent Cambridge and the major metropolitan areas in Europe.

Yet soon it became clear that effective policies could make other regions very attractive. Areas like Rhone Alpes, Aachen, Manchester and the Netherlands as a whole in Europe and North Carolina or Texas in the US with strong research facilities and supportive regional policies succeeded in replicating the initial market driven agglomerations. Later even traditional less favoured regions like Ireland, or seriously threatened countries like Finland in the early ‘90s could become attractive through policy intervention. Yet in other cases policy makers did not succeed, despite efforts, in attracting research facilities of MNCs.

Current data shows that multinational companies, who account for the greatest share of business R&D expenditure tend to invest based on analysis of locations. So the growing concentration of transnational R&D expenditure in the US is a source of concern, suggesting a decline in the global attractiveness of the EU as a location for R&D as compared to the US, and probably accelerated by the events of 9-11 after which US companies include security for staff and plant as an additional factor. This leads to the need for well conceived strategies and effective policies, if policy makers in a country or a region select the attraction of MNCs as a major tool for building research capacities.

6.5.2 EU perspectives and policies

All the above discussion highlights important drawbacks of Europe in comparison to the US in virtually all aspects of research capacity building. To face these trends, European Heads of State and Government meeting in the context of the European Council in Lisbon, under the Portuguese Presidency in the Council of the European Union, set themselves an important albeit complex and difficult vision: turn within 10 years (that is by 2010), Europe into the most competitive and dynamic knowledge based society and economy in the world, with more and better jobs, sustainable development, greater social cohesion; improvement of the labour market, better governance, improved life-long learning and people mobility. All this has to happen through the so-called “Open method of co-ordination and benchmarking”, a term that has been the topic ever since of many academic and political discussions (as it often happens with Community terminology introduced at the level of important policy discussions).

A proxy for the term “Open method of co-ordination” maybe that in principle it means that the process driving the “Lisbon Strategy” would be based on a loose co-ordination of efforts between Member States of the EU, that would not be governed by binding or uniform decisions, applicable to all players through Community legislation. Instead this has to based on the principle of a learning economy, and has to involve all players in a mutual learning process. This would also involve metrics via meaningful indicators to measure comparative performance, but would also include policy analyses to explain policy strategies and examine transferability of good practice.

The Lisbon Summit put Research and Innovation back on top of the policy agenda after a long under-representation as a priority policy issue. It also endorsed the proposed the Commission strategy for building a European Research Area (ERA) to achieve a more consistent and less fragmented European Research policy.

Later on, the European Council completed this goal by endorsing the Commission’s proposal for achieving an average of R&D investment at the level of 3% of GDP for all present EU Member States (Barcelona, March 2002). “Approaching 3 %” is an EU wide target and implies a major increase in European R&D Capacity, but there is little said about where that comes from. Also, not all current and future Member States will meet this target individually by 2010 but they should all contribute to the effort. If the Education system reformed tomorrow then it may just help to impact the picture by the time the Lisbon targets are to be met. Structural effects cannot explain fully the difference in R&D investment between the US and the EU. In most sectors, including medium and low-tech manufacturing as well as the services sector, European firms invest less in R&D as a proportion of sales than their US counterparts. EU enterprises tend to specialise in less technology-intensive products and services, and so risk losing competitiveness to more innovation-intensive rivals, notably in the non-high-tech sectors, which still constitute the bulk of the EU economy.

On this particular objective, the Commission has produced a new Communication that outlines critical policy areas where action is urgently needed if this objective were to be met by the Member States. It is worth noting that action is expected at European, national but also at regional and local level. This Communication addresses the need to eliminate fragmentation in framework conditions, reduce duplication and concentrate resources in Europe (in particular under the pressure exercised by the need of macroeconomic stability and reduced national public spending) thus building capacity in a way to make attractive to MNCs and talented scientists and thus enter into the virtuous circle that will allow Europe to compete with the US for scientifically productive leading edge research.

With consistent efforts now being deployed around the Union, it could be argued that the ERA project became one of the cornerstones of the Lisbon strategy, towards building the knowledge-based society in Europe. In this respect, it affects all policy levels, including that of the regions.

But there is always the reverse side of the medal. Not every region can be a leading research center, nor are the others condemned to decline. Some studies report that just 20% of the total economic benefit of innovation accrue to those who invest directly, making it attractive to wait to benefit for spill-over from someone else’s investment. All evidence seems to converge to the conclusion that any region benefits more from the collective research undertaken outside the region (this is valid even for the US as a whole) than from research in its own territory. Thus there is an alternative effective strategy for “waiting”. This does not suggest to abandon research capacity. On the contrary, it is important to make sure that these regions or companies invest in research but with the target of maintaining the absorptive capacity that will allow them to benefit from research done elsewhere.

6.6. Conclusions and Recommendations

There are several conclusions for policy making under uncertainty emerging from the topics analysed. Uncertainties are clear: they refer to competition for talents and the attraction of foreign R&D investments, sectoral trajectories, diminishing opportunities to raise public funding. The transition to the ERA, the lack of generally functioning recipes, rapid changes in technologies and the limitations in the transferability of good practices create more uncertainties than ever. Policy makers need to position their regions in clear categories:

- A ***leading edge***, thus knowing that sustainable high research capacity is needed; if a region manages to enter the virtuous circle of attraction of funding it can probably hope to remain in this position provided it will guarantee the necessary investment in the long term. Leapfrogging into this position is difficult and takes a high budget and a long term horizon to brand a region as research intensive, but if the means are available it is feasible.
- ***Intermediary regions,*** able to generate the absorptive capacities necessary to benefit from research done elsewhere and helping their enterprises modernise, even if they cannot access markets with world novel products. These regions will also have a cost to carry because there is no free riding in research spillovers. Investments will not need to be as high as in leading regions but they are necessary and will have to be effectively designed. The danger of building research capacity that does not ultimately contribute to absorptive capacities is very real.
- ***Static regions,*** saving resources for R&D but probably endangered in the long term, as they will see their competitive advantages gradually eroding.

Which instruments to use is the next very important question. Some uncertainty is attached to the instruments used for building the research capacity but even more to the impact of the instruments!

At the ***European level*** instruments have started to move in response to the 3% target. The mission of the supranational level in seen in its contribution to the reduction of the market fragmentation, so that business opportunities will improve and the European market becomes as attractive as that of the US. The efforts thus concentrate on framework conditions and only limited direct funding. The former refer to IPRs (in particular to adopt a Community patent and the discussion for a common position in the controversial issues of software and genetically modified organisms), stimulate entrepreneurship through a better internal market regulation and elimination of barriers to business development, streamline competition rules and provide a stable environment.

An array of policy framework conditions must be brought into play to reinforce the attractiveness and profitability of R&D investment. More attractive framework conditions include:

- access to a sufficient supply of quality human resources,
- elasticity in the system,
- a strong public research base; the excellence and scale of Europe's science base, including long-term research, are critical for the dynamics of the knowledge-based economy,
- an entrepreneurial culture, creating high-growth companies that create value from R&D investment and that are also new R&D performers. Spin-off companies in particular have been a key routes for exploitation,
- adequate intellectual property rights systems,
- a competitive environment with research,
- innovation-friendly regulations and competition rules,
- supportive financial markets,
- favourable fiscal environments and macro-economic stability.

The latter, notably financial incentives at the European level relate to:

- The funding of the promotion of excellence through the 6th FP, in an effort to give the opportunity and brand to the best research teams to network and become more attractive for industrial collaboration.
- Offer of development funds oriented towards research and technology to cohesion and accession countries in an effort to help them to stimulate research and create the necessary absorptive capacity.

But still at the European level there seems to be little interest to experiment with alternative ideas. The nature of funding and the need to use competing funding schemes are still different from the US. The integration and the ERA perspective are expected to alter things in that respect, to open up national funding to external collaborations (still intra-European) and may give private foundations (like the Volkswagen Foundation) or public-private initiatives a more prominent role. But even within the current schemes there is a need for policy experimentation. Social returns of the current tools are often questioned and this may be aggravated with the accession of the new member states. The idea of awards instead of grants (at least partially) to test the efficiency of the ex ante peer review system was mentioned as an interesting and innovative way of dealing with the selection process. Many more original ideas can be tested. Uncertainty can in that respect be reduced through the creation of more knowledge on the response to policy tools.

At the ***national level*** there is a new momentum trying to increase (in some countries) and improve the efficiency of R&D funding (in all member states, partly as a response to the ERA, the Barcelona target and the new Communications). Studying the alternative effects of direct and indirect intervention (fiscal schemes), increasingly adopting horizontal and cluster policies expected to increase benefits through externalities and the idea of testing new instruments like public technology procurement are indications in this direction. Yet, strategic capacity, which deals mainly with the system of mission-oriented agencies and public procurement, is a key capacity to mobilise and concentrate resources on targeted scientific or technological objectives of (supra) national interest, is controversial as we can observe both success and failures in it. Whatever the reasons of the weakness of strategic capacities in Europe (*laissez faire* ideology, federalism, fragmented markets), this is a major handicap in periods of changes and uncertainty.

Human resource development is a common element in all countries, while in cohesion and accession countries there is still a high element of infrastructural support. It is important for policy makers in the cohesion countries to assure that effective utilization of capacities built, while for the accession countries institutional reforms and emphasis on commercialisation are still very high on the agenda. At any rate the higher education efficiency is a responsibility of the national policy makers and seems to be the crucial element behind success at least in the cases of Ireland and Finland.

The discussion of experimentation suggesting new approaches mentioned in the European level above holds equally for the national level. Unfortunately and despite systematic evaluations in some countries we still don’t know enough about the effectiveness of measures and delivery mechanisms. New kinds of public private partnerships can also be tested. In addition national policies face additional challenges: uncertainty is increased when dependent on few technologies only and may lead to lock-ins (a case observed in France), yet all evidence suggests that concentration and clusters are necessary to maximize externalities and create high social returns. Also for the national level institutions matter a lot: frequent challenges and redesign may create confusion but be necessary for adaptation and reduction of malfunctioning.

At the ***regional level*** issues become more complex. Some regions dispose of the necessary administrative capability and the budgetary resources to exercise ambitious policies others not. Some regions are already beyond the 3% target and are concentrating their resources in excellence in an effort to compete with the US and other leading European regions for the attraction of foreign direct investment in research but also for cooperation with national champions or network with international champions. These are the regions that need to sustain this level of investment in order to remain to the leading edge and assure the renewal and possibly additional attraction of talented scientists. This may lead to an intra-European brain-drain that can lead to internal tensions, if not adequately managed.

It is also in these regions in particular that it is necessary for the firms to establish long-term contracts and collaborations with universities and research centres. It is a fact that businessmen want the rapid transformation of research results to practical results; however, they are also obliged to acknowledge that most of the time, the research results from universities demand a considerable amount of time to develop into practical solutions/products/services and by extension, the benefits are not immediate. Firms can help scientists introduce ideas to the market, while, at the same time, they can benefit from their access to new ideas, which are brought about in research laboratories and databases in universities, and to a wide range (both in terms of quality and quantity) of graduates with specialised skills.

But beside these highly performing regions it is now clear that all regions can benefit from research at least to the extent that they can help regional actors to absorb research results from elsewhere (which is a higher benefit compared to locally undertaken research). Tools like foresight, evaluations and technology assessments are very useful for the adoption of regional strategies. All regions would need to investigate issues like:

- Link more Research and Innovation at regional level.
- Develop more and better trained S&T human resources.
- Support the development of scientific infrastructure in a regional context.
- Reinforcement of the regional dimension of the Science and Society debate.
- Reinforcement of Community policy for regional development by undertaking appropriate research.
- Offer research and innovation services to the regions.
- Improve communication between experts and policy and makers.
- Introduce a regional dimension in research and innovation information systems.

But not all regions can manage returns from leading edge. The model of the small firm which invents a tool, patents it and hopes to obtain income by granting licences to other researchers who will pay only in case of success, functions only very rarely. Policy makers should also beware from a model of too high an acceleration, which the local actors cannot absorb.

More concrete ideas for policy makers discussed in the workshop were:

- To realise that the best researchers go where there is the best equipment. It is not possible to attract good people in poor environments.
- Purchase and lending rules of equipment can be improved and procurement can be better managed; there are differences in the rationale of purchase and maintenance of scientific equipment and other types of public procurement.
- It is important to eliminate any rigidities and barriers to move into new research.

One can also adopt new experimental forms of policy delivery at the regional level. Not only the ideas mentioned at the superior levels but also ways to make the territory more attractive can be tested: offering R&D grants to subsidiaries of MNCs, even if they are not research oriented may reinforce them in the corporate strategy and give them a new character ultimately also increasing social returns.

Regions have by now come to be recognised at large as significant players in the drive-up to the knowledge-economy in Europe. Building on their developing qualities, experience and commitment, they will be increasingly present in Europe's efforts for growth and competitiveness. Enhancing this capacity and equipping them with the appropriate tools and strategies remains a challenge for the Union.

Regions are supported in their efforts by an increasing number of European policies, of which research and innovation and cohesion ones, emerge as decisive. While there is no doubt that cohesion policy is playing a major role for the regions, research policy remains instrumental for creating the necessary conditions for advancing the regions in the knowledge-based economy. Together with innovation and education and training, research brings a new message to regional economies, allowing for new forms of advancement that keep pace with local but also international developments. Beyond regional development, regional research and innovation policies and initiatives may provide the essential ingredients for the emergence of agglomeration economies and of successful industrial clusters.

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Appendix:
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The MUSCIPOLI group has identified a number of activities, under the heading of Managing with Uncertainty in Science Policy. These include: three international workshops: Priority Themes and Topics, Support for Transdisciplinary Research, and Building European Research Capacity, handbook of policy guidelines based on experiences from a series of workshops.