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Accompanying the

GREEN PAPER

The European Research Area: New Perspectives

{COM(2007) 161 final}

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List of Acronyms

AC	Associated Countries
ACP-EU	Africa Carribean Pacific – European Union
AIDS	Acquired Immuno-Deficiency Syndrome
ALCUE	Latin America and the Caribbean and EU - bi regional dialogues
Article 169	Art. 169 of the EU Treaty enables the EU to participate as an equal partner in R&D programmes conducted by several MS, combining various national and regional programmes into a single joint programme.
ASIF	Report published by the University of Manchester in 2002, assessing the socio-economic implications of the Framework Programme
ASTP	Association of European Science and Technology Transfer Professionals
ATP	Advanced Technology Platform
AUTM	Association of University Technology Managers: a nonprofit association of technology managers and business executives who manage intellectual property.
BERD	Business Expenditure on R&D
CCCTB	Common Consolidated Corporate Tax Base
CEEC	Central and Eastern European Countries
CENIT	Spanish National Strategic Consortia for Technical Research
CERN	*l'Organisation Européenne pour la Recherche Nucléaire.*
CIP	Competitiveness and Innovation programme
CIPAST	Citizens Participation in Science and Technology
CLEPA	European Association of Automotive Suppliers
COST	European cooperation in the field of scientific and technical research
CREST	The Scientific and Technical Research Committee (CREST) advises the Research Council and the European Commission on issues of European RTD policy.
CRP's	Cooperative Research Processes
CSO	Civil Society Organisation
DEISA	Launched in 2005, it is a grid of 11 of the most important national supercomputers and is linked to the USA supercomputing infrastructure (TeraGrid)
DG BUDG	European Commission Directorate General for Budget
DG MARKT	European Commission Directorate General Internal Market and Services
DRM	Digital rights management
EARTO	European Association of Research and Technology Organisations
EDCTP	European Developing Countries Clinical Trials Partnerships
EFDA	European Fusion Development Agreement
EFMN	Monitoring system on foresight in Europe
EFSRI	The European Strategy Forum for Research Infrastructures
EGEEII	Enabling Grids for E-Science is the world's largest production grid infrastructure addressing 10 different areas of science, linking 50 research organisations, having started its second two-year phase in 2006.
EHEA	European Higher Education Area
EIB	European Investment Bank
EIF	European Investment Fund
EIMS	Evaluation Information Management Systems
EIROforum	EIROforum is a collaboration between seven European intergovernmental scientific research organisations to pursue joint initiatives, combine resources, and share best practices
EMBL	Euorpean Molecular Biology Laboratory
EMBO	European Molecular Biology Organization
Enwise	Expert Group (*En*large *W*omen *I*n *S*cience to *E*ast)
EPLA	European Patent Litigation Agreement
EPO	European Patent Office
ERA	European Research Area
ERA-MORE	Pan-European Researchers Mobility Portal and the European Network of Mobility Centres

ERA-NET	European Research Area Network
ESA	European Space Agency
ESF	European Science Foundation
ESFRI	European Strategy Forum for Research Infrastructures, involving Member States and the Commission
ESO	European Southern Observatory
ESRF	European synchrotron radiation facility
ETAN	Experts Working Group on Women and Science,
ETF Start up facility	The European Technology Facility Startup Facility aims to provide risk capital to innovative SMEs through investment in relevant specialised venture capital funds. ETF Startup will reinforce the existing facilities by targeting a segment of the venture capital market with a higher inherent investment risk, notably innovative SME's at establishment and early stages
ETP	European Technology Platforms
EU	European Union
EU/MS	European Union/Member States
EUA	European University Association
EUREC	European Network of Research Ethics Committees
EUREKA	A pan-European network for market-oriented, industrial R&D
EuroHORCs	European Heads of Research Councils
EUROSTARS	To support R&D performing entrepreneurs, by offering funding for their research activities, enabling them to compete internationally and become leaders in their sectors.
EUROSTAT	European Community Statistics Office - gathers and analyse figures from the different European statistics offices in order to provide comparable and harmonised data to the European Institutions so they can define, implement and analyse Community policies.
FDI	Foreign Direct Investment
FEAST initiative	Initiative Forum on European-Australian Science & Technology Cooperation
FFG	'Österreichische Forschungsförderungsgesellschaft' responsible for Austrian Thematic programmes
FP6	6th Framework Programme
FP7	7th Framework Programme
FTE	Full time equivalent
GAP	Gender Action Plan FP6 inititative to promote gender equality
GBOARD	Government budget appropriations or outlays on R&D
GDP	Gross domestic product
GDR	German Democratic Republic
GÉANT2	A pan-European communication infrastructure for the research and education community, launched in September 2004, is the first network in the world to run at 10 Gb/s.
GERD	Gross Domestic Expenditure on R&D
HERD	Higher education research and development
HIV	Human immuno deficiency virus
i2010	Commission's policy to encourage knowledge and innovation to boost growth and create more better quality jobs, under the Lisbon strategy
ICT	Information Communication Technology
IISER	Integrated Information System on European Researchers
ILL	Institut Laue-Langevin is an international research centre at the leading edge of neutron science and technology.
INCO	Specific International Scientific Cooperation Activities: Mutually beneficial international cooperation activities between the Community and its Member States and INCO target countries and other third countries
IPR	Intellectual Property Rights
IP's	Intellectual Properties

IPTS	The Institute for Prospective Technological Studies (IPTS) is one of the seven scientific institutes of the European Commission's Joint Research Centre (JRC)
IRIM	Industrial Research Investment Monitoring
IST	Information Society Technologies
IST	Innovation, Science & Technology
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor
JRC	Joint Research Centre
JTG	Joint Technology Group
JTI	Joint Technology Initiative
KLASTRY	Czech Republic National Cluster Strategy
KT	Knowledge Transfer
LERU	League of European Research Universities
M€	Million Euros
MDG's	Eight Millennium Development Goals (MDGs) – which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015
MEDA	MEDA Euro-Mediterannean cooperation Programme for cooperation and free exchange of goods
MNE's	Multi National Enterprises
MS	Member States
NEC	National Ethics Councils
NEC Forum	Forum of National Ethics Councils
NIS	New Independent States
NoE	Networks of Excellence
OECD	Organization for Economic Cooperation and Development
OMC	Open method of coordination' introduced by the European Council of Lisbon in 2000. Designed to help MS progress jointly in the refoms needed to achieve the Lisbon goals.
PhD	Doctor of Philosophy
PPP	Purchasing power parities, according to OECD data
PPP	Public-private partnership
PRO's	Public Research Organisations
ProTon	ProTon public research organisation technology transfer offices
PVA's	Patentverwertungsagenturen – Patent exploitation agencies
R&D	Research and development
R&D&I	Research, development and innovation
REC	Research Ethics Committees
RPF	Cypriot Framework programme Thematic actions
RTD	Research and technological development
RTO	Research and Technology Organisation
S&E	Science and Engineering
S&T	Science and Technology
SCAR	Scientific Committee on Agricultural Research
SCI	Science Citation Index
SI	Strategic Intelligence
SINAPSE	SINAPSE is a web communication platform, being developed by the Commission, in order to promote a more efficient use of scientific information and expertise in support of policy making.
SME	Small and medium sized enterprises
SPLT	Substantive Patent Law Treaty being drafted by the WIPO on Intellectual property rights.
SRA	Strategic Research Agenda
SSP	Scientific Support for Policy
STOA	Scientific Technology Options Assessment – Assessment of Science & Technology policy options for the European Parliament
TBP	Technology Balance of Payments

TIP	Technology Implementation Plans
TP	Technology platform
Triadic patents	A set of patents filed at the EPO, JPO, and USPTO to protect the same invention - often considered high quality patents -to be exploited globally
TT	Technology Transfer
TTO's	Technology Transfer Offices
UBR	University based research
UK	United Kingdom
Umbrellas	Thematic networks to generate smaller EUREKA projects
UN	United Nations
UNICE	Union of Industrial and Employers' Confederations of Europe, renamed BUSINESSEUROPE
US	United States (of America)
VC	Venture Capital
WIPO	World Intellectual Property Organization
WSSD	World Summit on Sustainable Development

Executive summary

This document provides supporting material for the Green Paper on the European Research Area (ERA). It outlines the history and evolution of the ERA initiative, takes stock of actions implemented so far at EU and national level, and examines where Europe is situated in relation to the original ERA objectives.

Context and evolution

Since the launch of ERA, the context has evolved considerably and a number of trends already apparent in 2000 have further intensified:

- ✓ Globalisation has accelerated, with knowledge production and R&D acting as key components of this new global dynamic.
- ✓ Awareness has grown of various socio-economic challenges – such as increased socio-economic disparities within the EU, climate change, ageing, and risks of infectious diseases – and there is a consensus that more and stronger concerted action is needed at EU and global level, notably in science and technology.
- ✓ The European research landscape has evolved in the last few years, notably with the launching of new measures such as the European Research Council and the European Institute of Technology, but also through various ERA specific measures, as well as the wider diversity of scientific cultures that have come with the expanded EU.

Within this changing context, the ERA concept itself has also been subject to gradual changes. Its initial focus was on how to improve the efficiency and effectiveness of fragmented research efforts and systems in Europe, and how to get a better return on investment. Gradually, its scope was broadened to include the need for more public and private investment in research, and later to encompass the necessity for improving coherence and synergies between research and other EU policies in order to achieve the renewed Lisbon strategy.

What has been done to build ERA

In the last few years, and particularly with the measures implemented in the 6th Framework Programme, ERA has been transformed from a theoretical concept to a practical policy approach embodying many different dimensions. However, even though the policy context has evolved, the original ERA objectives as defined at the beginning of the millennium are still valid. The core objectives – how to overcome Europe's S&T weaknesses and fragmentation, and achieve a coherent and effective European research policy – are still at the heart of the ERA concept.

ERA concerns both the Community and the Member States (including their regions) and the response has been significant at both levels. At EU level a number of actions have been launched since 2000 in support of ERA, notably through the 6th Framework Programme. Progress on some of these actions has been good though somewhat restrained at times, while for others it has been more limited, pointing to the limits of what can be achieved at Community level alone.

- ✓ One of the notable developments has been the ERA-NET instrument which has made a start at addressing the inefficiency and fragmentation inherent in a system comprising numerous research funding schemes, spread across policy levels. Though the interest it provoked suggests that it responded to existing needs, the volume of funding involved in the resulting joint activities is still marginal. Moreover, national and regional programme 'owners' are reluctant to restructure their programmes in a way which would enable the development of genuine joint programmes.

- ✓ Another area where good progress has been made is research infrastructures. A first major milestone was reached with the adoption of the European Strategy Forum for Research Infrastructures (ESFRI) Roadmap. However, the Roadmap will only be a success if the proposed projects are realised. For this to happen there is still a long way to go: New approaches are required - new legal, institutional and financial tools need to be developed.
- ✓ In the area of international cooperation, ITER[1] has been a very visible success, and has demonstrated that Europe has the will and the capacity for leadership to address global challenges with partners around the world. However, while Europe is increasingly engaged in global science, research and infrastructure initiatives, these initiatives are far from systematic and often poorly coordinated with those of the Member States.
- ✓ Despite the success of important measures aimed at better exploiting human resources (such as the Marie Curie scheme, the European Charter for Researchers and the scientific visa package), Europe still lacks an open, competitive and attractive labour market for researchers. Some bright researchers and S&T graduates are still leaving Europe, others do not enter a research career in Europe or exit early, others miss opportunities to move into positions where their capacities could be better used and developed.
- ✓ Another problematic area is private investment in research. Although efforts have been made to improve framework conditions and stimulate investment, Europe's business-funded research intensity has not increased since 2000 according to the latest data, and the gap between the EU and its major competitor has not been reduced.

At national level too, Member States have been involved in implementing actions which can help achieve ERA, for example:

- ✓ In recent years, Member State's strategies and policies for stimulating R&D activity have evolved considerably towards richer and more complex mixes of measures, tailored to the particular situation of the Member State in question. However, it still remains to be seen whether the pace of national policy reform will be sufficient to address the challenges at hand.
- ✓ Some convergence in national policy making is materialising, driven in part by discussion and interaction between Member States and the Community level, such as through the Open Method of Coordination (OMC - launched in the context of the 3% Action Plan and overseen by CREST since 2003) or as a follow-up to Commission Communications.
- ✓ Trans-national and international cooperation are elements of most Member State research policies but, with some exceptions, still remain marginal in regard to the overall policy mix. In general, there is little evidence that national policy makers have taken ownership of the ERA concept, or have advanced far in their practical reflections on how national policy can contribute to constructing ERA, by building policy coherence across borders and across policy levels.

Thus, progress at national level has also been mixed.

Where are we now?

The mixed progress to date on ERA, combined with the new global context for science and technology, mean that research actors are now facing a series of important challenges.

Universities, at the intersection of the ERA and European Higher Education Area, play a prominent role in knowledge production and dissemination. Universities across the EU

[1] International Thermonuclear Experimental Reactor

employ about 37% of researchers, compared to around 15% in the US and 26% in Japan. However, evidence suggests that modernisation involving, for example, increased autonomy and institutional accountability, more structured links with non university partners, etc, may help to boost their capacity to generate high standards, cutting-edge research and act as powerful catalysts for innovation. Research and technology organisations play a key role in the European research landscape, as they exert an impact not only regarding R&D *per se* but also on education, training and innovation, and are therefore contributing significantly to enhance Europe's competitiveness.

Researchers are a vital asset. The business sector in Europe currently employs fewer researchers than it does in other regions of the world – around 50% of its researchers work in the business sector, compared with nearly 70% in Japan and 80% in the US. Europe would do well to retain more of its scientists while also attracting top scientists from abroad. Networking EU researchers abroad could be a useful step to keep them in touch with developments in Europe, and make their return more likely. In this regard, enhanced inter-sectoral mobility, in terms of two-way flows between private and public sector, would also be welcome.

As for the private sector, the EU still lags behind the US and Japan in terms of business R&D spending. The percentage of R&D funded by business was 55% for EU-27 in 2004, compared with 64% in the US and 75% in Japan. Thus, there is further room for improving the framework conditions for research, for example, by making the IPR system more cost-effective and legally certain, and by governments better organising the procurement of R&D services to steer private research into responding to future public needs and decrease time-to-market for innovative products.

The potential for strengthening the interactions between the various research stakeholders remains quite high in Europe. The landscape is rather complex, with research being carried out in industry, universities and other public research centres, and transferred to potential users in a number of ways, including licensing and the creation of spin-offs by universities. R&D sponsors have an increasingly important role. Cross-border interactions clearly need to be promoted, as well as measures to enhance the co-production and transfer of knowledge.

Regarding overall performance of the European research system, there is still much to do. Not much progress has been made towards the EU R&D investment target of 3% of GDP (two thirds of which to come from private sources) since this objective was set in 2002. The deficit in R&D intensity of the EU versus the US has not been reduced - on the contrary - and China will have probably caught up with the EU-27 by 2009 in terms of its share of GDP devoted to R&D. Comparing absolute amounts of R&D spending between world-regions of similar size shows that the absolute R&D expenditure gap between the EU and the US has not been reduced (standing at € 76 billion), while a similar gap is emerging with several dynamic Asian economies (China, Japan, South-Korea, Taiwan and Singapore).[2] In addition, substantial amounts of R&D spending are flowing out of Europe. As a result, the EU's share in world R&D expenditure is under pressure.

While the EU is nominally the world's largest producer of peer reviewed scientific articles, this is not the case when one adjusts for size and input. Moreover, recent evidence on citation impact and highly-cited publications shows that Europe's scientific impact still lags significantly behind that of the US in 35 out of 37 scientific sub-fields, and that it has not been improving in this regard since the mid nineties. Europe's performance in terms of patenting and high technology trade is fairly stable. Europe still has a lower percentage of high tech products in its exports - 18% versus 27% for the US and 22% for Japan. The 2006

[2] This figure is for the year 2004, and is expressed in real terms and adjusted for differences in purchasing power (in million PPS, at 2002 prices).

European Innovation Scoreboard provides a broader assessment of innovative performance, and indicates that there is still a gap between Europe and the US and Japan, although there are signs that it is closing.

Thus far, ERA has proven itself to be a powerful mobilising concept, bringing several important achievements and developments in the European research landscape. However, seven years on, the many challenges faced by EU research actors and the problems of EU science and technology performance indicate that ERA has yet to achieve its full potential. Doing so now will help Europe tackle many significant challenges it faces and to which research can help to provide solutions.

Introduction

This document is a Working Paper of the Services accompanying the Green Paper on the European Research Area (ERA). It brings together a number of elements supporting the issues raised in the Green Paper, and highlights various facts in order to facilitate the debate. While research and innovation policies are closely linked and interdependent and need to be implemented coherently as part of a wider set of policy instruments, the focus of this document is on European research performance.

The document is structured into three chapters. In order to answer the question 'what needs to be done?' Chapter 1 takes the reader back to the context in which ERA was launched and the objectives defined for ERA at the beginning of the millennium.[3] It describes how several years of implementing ERA have transformed it from a theoretical concept to a practical policy from which lessons can be learnt. The paper also describes how at the same time, the overall policy context has evolved, concluding that the three objectives defined for ERA in 2002 are still valid.[4]

Chapter 2 goes on to look at 'what has been done' so far to achieve these three objectives by presenting a stock-taking of the actions implemented in support of ERA. It outlines the actions that have been undertaken at EU level, at Member State level and at international level, and provides a factual description of what has been done so far identifying where difficulties lie.

The diagnosis 'where we are now' treated in Chapter 3**,** attempts to describe the new context of European research seven years after the ERA Communication, and to analyse how various aspects of the European research system are performing on the basis of facts and figures. Three aspects are highlighted: the new global context in which ERA must be achieved; the shifting roles of actors and stakeholders involved in European research and the implications for ERA; and finally, Europe's progress in terms of research effort and performance as related to some of the key objectives of ERA.

This Working Paper of the Services is not intended to be exhaustive in its analysis, but - as a companion to the Green Paper - it aims to help spark the debate by presenting factual analyses which should be taken into account when designing new policy actions or adapting existing measures.

Despite the widespread popularity of the ERA concept, there is clearly a need to further deepen the analysis of the performance of the national and European research systems and to assess the implications of the issues and challenges that emerge for ERA. The distribution of, and access to, strategic intelligence among the key policy actors within the European Research Area will be an important tool to satisfy this need, alongside a stronger involvement of the academic community in the conceptualisation of ERA.

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[3] Communication 'Towards a European Research Area' (COM(2000) 6, 18.1.2000); Communication 'The international dimension of the European Research Area' (COM(2001) 346, 25.6.2001); Communication 'The ERA: providing new momentum' (COM(2002) 565, 16.10.2002).

[4] Communication COM(2002) 565, p. 4 mentions the following three strategic and interlinked objectives of ERA: (1) the creation of an 'internal market' for research; (2) a restructuring of the European research fabric, in particular by improved co-ordination of national research activities and policies; (3) the development of a truly European research policy.

Chapter 1: What was originally intended – Building the European Research Area

This Chapter recalls the context in which the European Research Area (ERA) was launched and the objectives defined. While implementing ERA, the policy context has evolved over the past seven years and different dimensions have come to the forefront. Before outlining the policy actions shaping ERA in the past years in chapter 2, this chapter will take the reader back to the launch of ERA in 2000 in order to make the context and objectives understood.

1.1. The making of a concept: How the European Research Area came to be

Since 2000, the European Research Area has become the mantra for European and Member State research policies. The underlying idea of ERA was not new.[5] The European Research Area idea is a rediscovery of a concept dating back to the 1970s. It was reanimated several times, but was never actually implemented. ERA, as perceived since the 1970s, is a vision about coordinating national research activities and policies and creating an internal market for research with the free circulation of researchers, ideas and technology. However, it was only in 2000 that the concept was put on the political agenda and gained visibility. The Commission Communication 'Towards a European Research Area' generated the necessary momentum while the political context played a major role, creating a threefold awareness: firstly of the major challenges facing Europe, secondly of the potential of science and technology (S&T) to deliver solutions to these challenges and, finally, of the weaknesses of the European S&T system which needed to be overcome to realise this potential.[6] The Lisbon European Council in March 2000 recognised ERA as an objective of the EU and paved the way for its implementation.

The political context in 2000 was favourable to the realisation of ERA

In 2000, the economic and political context was favourable to the identification of ERA as a shared objective. At both academic and political level, awareness grew that Europe was facing significant economic, social and environmental challenges. Despite the optimism shared at the Lisbon European Council meeting in 2000, economic growth was slow, and Europe's competitive position was feeble. Not enough jobs were being created, and too few of them were highly skilled. Substantial regional diversity and inequality characterised the European Union, despite the general perception of a higher quality of life compared to many other world regions. First signs of the long-announced demographic challenge were emerging: birth rates were lower and the population was ageing.[7] Awareness was rising that the health-risks to from serious diseases (such as cancer, diabetes, HIV/AIDS etc.), was putting pressure on health care systems. Furthermore, there was rising awareness that the environment was being degraded – climate change, loss of biodiversity and water pollution were issues of major concern to European citizens and policy makers.

This diagnosis of the condition of Europe came along with another belief. It was around the turn of the century that a new policy context emerged, based on the conviction that the key to

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[5] Michel André, *L'Espace Européen de la Recherche: Historie d'une Idée*, In: Journal of European Integration History, Vol. 12, No 2, 2006, pp. 131-150.

[6] European Commission, Communication "Towards a European Research Area" (COM(2000) 6, 18.1.2000). The subsequent conclusions of the Lisbon Council of March 2000 endorsed the idea of ERA and the objectives set out in this Communication. ERA became a "key component of the Lisbon strategy" (European Commission, Communication "The European Research Area: Providing New Momentum" (COM(2002) 565, 16.10.2002, p. 3).

[7] Data: Eurostat.

facing these challenges consisted of making the transition to a knowledge-based economy, notably through more and better investment in the knowledge triangle of research, education and innovation. Society held high expectations for research as more and better research and development (R&D) appeared capable of improving economic performance, promoting employment, improving public health, tackling demographic, cohesion and environmental challenges, and so on.

At the Lisbon Summit in 2000, Europe formulated its response to the economic and social challenges. Reflecting the concerns of its citizens, political leaders set an ambitious long-term agenda for change. The European Research Area became a 'key component of the Lisbon strategy.'[8] The ERA objectives related to the 'coordination and better integration of research activities at national and European level, non-bureaucratic approach of instruments and means, patent protection'. The new ERA as defined in Lisbon had its roots in the wider spectrum of Community policies. The comprehensive Lisbon goals emphasised the key role of the transition to a knowledge-based economy by securing sustainable growth, more and better jobs and greater social cohesion. Research and innovation were expected to play a major role in this endeavour.

1.2. The evolution of a concept: Drivers of the ERA objectives between 2000 and 2006

This section gives an overview of the main Commission policy documents on ERA between 2000 and 2006: the Communication 'Towards a European Research Area' the Decision of the European Parliament and of the Council, concerning the Sixth Framework Programme (FP6) of the European Community for research, technological development and demonstration activities, contributing to the creation of the European Research Area and to innovation (2002 to 2006), the Communication 'The ERA: Providing New Momentum'[9] and the Communication 'Building the ERA of Knowledge for Growth'. [10,11,12]

Identifying the weaknesses of research in Europe

In its Communication of 2000, the Commission analysed the condition of research in Europe.[13] It concluded that it did not perform too well. A number of factors prevented Europe from achieving its full potential. As long as these factors were not adequately addressed, the part that science and technology (S&T) could play in addressing the challenges would remain limited. The Commission identified three major weaknesses:

- ✓ Insufficient funding: As far as overall research and development (R&D) expenditure was concerned, the EU seriously lagged behind the US in absolute terms, and behind both the US and Japan in terms of R&D intensity. In addition, R&D intensity was not increasing in the EU, while the US, Japan, and a number of newly emerging, mainly Asian competitors were seeing their figures rising. The share of R&D financed by industry was considered too small.

- ✓ The lack of an environment which stimulates research and exploitation of results: The EU research framework conditions (e.g. fiscal incentives for research, intellectual property protection, venture capital availability, market policy, competition policy, etc.) were sub-

[8] COM(2002) 565, 16.10.2002, p. 3.
[9] COM(2002) 565, 16.10.2002.
[10] COM(2000) 6, 18.1.2000.
[11] Decision No 1513/2002/EC of the European Parliament and of the Council of 27 June 2002.
[12] COM(2005) 118, 6.4.2005.
[13] European Commission, Communication "Towards a European Research Area" (COM (2000) 6, 18.1.2000).

optimal and not conducive to sufficient research or to its exploitation via new products, processes and services of new knowledge.[14]

- ✓ The fragmentation of research activities and the dispersal of resources: research and innovation policies were pursued largely independently – at national, EU and regional levels – leading to a governance failure characterised by poor integration and coordination between these different levels and sub-optimal allocation of resources. Furthermore, national activities were governed by 15 (and then 25) varying legislative, regulatory and financial structures, with little or no coordination between them.

The idea of a European Research Area grew out of a need to deal with these science and technology (S&T) weaknesses. ERA was seen as a policy approach which would reinvigorate research by stimulating investment in science and technology. By developing a more dynamic configuration of European and national research programs and policies, it would be possible to progress towards a real European research policy.

The answer of ERA in 2000

The European Research Area was seen in 2000 as a powerful concept which, once implemented, would facilitate the progress towards a better organization of research activities and policies in Europe. To this end, the Commission defined a number of implementing measures in its Communication 'Towards a European Research Area' in 2000. According to the Communication, these were:[15]

- ✓ Networking of existing centres of excellence and creation of virtual centres.
- ✓ Definition of a European approach to research facilities.
- ✓ More co-ordinated implementation of national and European research programmes.
- ✓ Better use of instruments and resources to encourage investment in research and innovation.
- ✓ Establishment of a common system of scientific and technical reference for the implementation of policies.
- ✓ More abundant and more mobile human resources.
- ✓ Greater European cohesion in research based experience of knowledge transfer at regional and local levels.
- ✓ Bringing together scientific communities, companies and researchers of Western and Eastern Europe.
- ✓ Improving the attraction of Europe for researchers from the rest of the world.
- ✓ Promotion of common social and ethical values in scientific and technological matters.

[14] Frequently seen as an explanation for the 'European Paradox'. See European Commission, First European Report on S&T Indicators, Luxembourg 1993; European Commission, Second European Report on S&T Indicators, Luxembourg 1997; European Commission, Green Paper on Innovation, 1994.
[15] COM(2000) 6, 18.1.2000.

A fully fledged concept in 2002

The subsequent Communication 'European Research Area: Providing New Momentum' of 2002 brought further clarity to the concept itself, and defined three strategic and interlinked objectives of ERA:[16]

- ✓ The creation of an 'internal market' for research – an area of free movement of knowledge, researchers and technology, which would contribute to an increasing co-operation, and would stimulate competition and a better allocation of the resources.
- ✓ A restructuring of the European research fabric; in particular by improved co-ordination of national research activities and policies.
- ✓ The development of a European research policy which would not only address the funding of the research activities, but also all relevant aspects of other EU and national policies.[17]

ERA thus focused on research policy and on its internal organisation. Although the ERA concept and objectives regrouped the importance of knowledge transfer and of some factors affecting the exploitation of research results, the need for a broad based policy approach seeking more coherence and synergy between research, innovation and education policies was recognized and addressed later.

At the operational level, the range of implementing measures set up already in 2000 was identified as necessary to achieve these strategic objectives. Since then, concrete actions have been undertaken and are still being pursued in nearly all areas, with different degrees of progress depending on the nature of the action, the lead-time involved and difficulties encountered.

The Commission proposal for the 6th Framework Programme (FP6), presented in 2001, was conceived as the main Community instrument to realise ERA and included new types of actions designed to have a structuring effect on national research efforts and systems. Building on the experience of the Sixth and Seventh Framework Programmes (FP6, FP7) includes the continuation of actions introduced in FP6 as well as new actions to further advance ERA objectives, notably by supporting larger scale integration of research efforts, and promoting excellence through competition.

ERA-related initiatives published after the launch of the ERA concept

After the two communications in 2000 and 2002 outlining the concept of ERA, a series of ERA-related communications were published dealing with the different dimensions of a European Research Area. One of these communications which dealt with the international dimension emphasised the fact that a European Research Area is not to be perceived as a closed system, but instead as an open one based on partnership and dialogue with researchers from all over the world, in coordination with and among the Member States. This includes the promotion of trans-regional scientific partnerships, mobility of scientists between Europe and third countries and establishing scientific and technological cooperation in order to contribute to fair and sustainable development and socio-economic progress for all partners.[18]

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[16] European Commission, Communication 'The European Research Area: Providing New Momentum' (COM (2002) 565, 16.10.2002.
[17] COM(2002) 565, 16.10.2002, p. 4.
[18] COM(2001) 346, 25.6.2001, p.19, 'The International Dimension of the European Research Area'.

Another communication dealing with the regional dimension of ERA emphasised the need for research policy to involve Europe's regions more explicitly in the drive to create the knowledge-economy. Enhancing their capacity to develop a research and innovation agenda adapted to the specific needs of the region, means equipping them with the appropriate tools and strategies. That way, regions will be able to contribute to Europe's efforts for growth and competitiveness and contribute to strengthening the ERA fabric.[19]

The 2003 Communication dealing with the role of universities underlined the dramatic changes in role and nature and the implications for universities, including their changing contribution to society.[20] Related communications dealt with research as a profession, mobility of researchers, and the importance of basic research for Europe.[21,22,23]

Table 1.1: Overview of EC initiatives related to ERA

2000		
Communication	'Towards a European Research Area'	COM(2000)6
2001		
Communication	'A Mobility Strategy for the European Research Area'	COM(2001)331
Communication	'The International Dimension of the European Research Area'	COM(2001)346
Communication	'The Regional Dimension of the European Research Area'	COM(2001)549
2002		
Decision	Decision of the European Parliament and the Council concerning the Sixth Framework Programme of the European Community for research, technological development and demonstration activities contributing to the creation of the European Research Area and to innovation (2002-2006)	Decision No 1513/2002/EC
Communication	'More Research for Europe: Towards 3% GDP'	COM(2002)499
Communication	'The ERA: Providing New Momentum'	COM(2002)565
2003		
Communication	'The Role of the Universities in the Europe of Knowledge'	COM(2003)58
Communication	'Investing in Research: An Action Plan for Europe'	COM(2003)226
Communication	'Researchers in the European Research Area: One Profession, Multiple Careers'	COM(2003)436
2004		
Communication	'Europe and Basic Research'	COM(2004)9
2005		
Communication	'Building the ERA of Knowledge for Growth'	COM(2005)118
Communication	'More Research and Innovation - Investing for Growth and Employment: A Common Approach'	COM(2005)488
Communication	'i2010 – A European Information Society for Growth and Employment'	COM(2005)229
2006		
Decision	Decision of the European Parliament and the Council Establishing a Competitiveness and Innovation Framework Programme (2007 to 2013)	Decision No 1639/2006/EC
Commission Proposal	Proposal for a Regulation of the European Parliament and the Council Establishing the European Institute of Technology	COM(2006)604
Communication	'The European Institute of Technology: Further Steps Towards its Creation'	COM(2006)276
Communication	'Implementing the Renewed Partnership for Growth and Jobs - Developing a Knowledge Flagship: The European Institute of Technology'	COM(2006)77
Decision	Decision of the European Parliament and the Council concerning the	Decision No

[19] COM(2001) 549, 3.10.2001, p.27, 'The Regional Dimension of the European Research Area'.
[20] COM(2003) 58, 5.2.2003, p.22, 'The Role of Universities in the Europe of Knowledge'.
[21] COM(2003) 436, 18.7.2003 'Researchers in the European Research Area: One Profession, Multiple Careers'.
[22] COM(2001) 331, 20.6.2001 'A Mobility Strategy for the European Research Area'.
[23] COM(2004) 9, 14.1.2004 'Europe and Basic Research'.

	7th Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) 'Building the European Research Area of Knowledge for Growth'	1982/2006/EC

The need for increased investment in research was addressed in the 2002 Communication and the 2003 Action Plan.[24,25] These communications both concluded that improving the effectiveness of the European research and development and innovation system should go hand in hand with addressing the EU's underinvestment in R&D. The target agreed upon during the Barcelona Summit in 2002, was 3% of gross domestic product (GDP) to be achieved by 2010, with an increased share of business funding that should reach two thirds of total R&D expenditure.[26]

The 2005 Communication entitled 'Building the ERA of Knowledge for Growth' and published together with the FP7 proposal, underlines thoroughly the need for cooperation between European policies so as to contribute to the Lisbon objectives and the renewed Lisbon strategy.[27] It is in this context that the concept of the 'knowledge triangle' is introduced.

1.3. Highlights

- ✓ Since its launch in 2000 the ERA concept has been subject to gradual changes.
- ✓ The initial focus of ERA was on how to improve the efficiency and effectiveness of research efforts and systems in Europe, whereby research was given a key role at the Lisbon European Council meeting to achieve the Lisbon Agenda by 2010.
- ✓ Gradually, the scope was extended to include the need for more public and private investment in research (which found its most prominent expression in the Barcelona objectives of 2002).[28]
- ✓ Finally, the 2005 ERA Communication emphasised the need for more coherence and synergies between research policies and the EU policies in order to achieve the renewed Lisbon strategy.[29] This was an explicit recognition that ERA is embedded into the concept of the knowledge triangle - in a context which obliges consideration of the broader impact of research (innovation, the internal market, financial markets, higher education systems, etc.) and not only the specific research outputs.
- ✓ Looking back, it can be said that several years of developing ERA have transformed it from a theoretical concept to a practical policy approach, embodying many different dimensions.
- ✓ At the same time, even though the policy context has evolved, the original ERA objectives – how to overcome Europe's S&T weaknesses and to achieve a coherent and effective European research policy – as defined at the beginning of the millennium are still valid.

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[24] COM(2002) 499, 11.9.2002 'More Research for Europe – Towards 3% of GDP'.
[25] COM(2003) 226, 30.4.2003 'Investing in Research: an Action Plan for Europe'.
[26] COM(2002) 499, 11.9.2002 'More Research for Europe – Towards 3% of GDP'.
[27] COM(2005) 118, 6.4.2005 'Building the ERA of Knowledge for Growth'.
[28] European Commission, Communication 'More Research for Europe: Towards 3% of GDP' - COM(2002) 499, 11.9.2002.
[29] Published as an introduction to the FP7 proposals, the 2005 communication 'Building the ERA of Knowledge for Growth' (COM(2005)118 of 06/04/2005) foresees the following objectives of ERA: (i) delivering on the Lisbon objectives; (ii) putting the 'knowledge triangle' of research, education and innovation to work; (iii) mobilising EU financial instruments at the service of knowledge for growth. The central action on the research side of 'knowledge triangle' is the new FP7.

The next chapter will take stock of the actions that have been undertaken at EU level, at Member State level and at international level, in order to achieve these objectives in the past years.

Chapter 2: What has been done

The aim of this chapter – a bridge between chapters 1 and 3 – is to provide an overview of European Research Area actions that have been taken between 2000 and 2007.

Even though the Framework Programme (FP) is crucial for the realisation of ERA, the scope of ERA goes way beyond the FP, and indeed beyond EU initiatives. Thus, actions that have to some extent contributed to ERA, can be identified in diverse quarters as shown below.

The chapter presents a stocktaking of progress towards achievement of the objectives outlined in both the original 2000 ERA communication and the 2001 communication on the international dimension of ERA. It also reports on the contributions of national policies to the strengthening of ERA.

This is the first time that a review of ERA actions has been produced. Such stocktaking is overdue and also difficult to undertake as FP6 (the 6th Framework Programme) is still in progress and many of its actions which support ERA development are still in their early stages. Furthermore, many of the initiatives taken at EU or national level do not have as a sole (or main) objective the furthering of the ERA.

2.1 Stocktaking of ERA actions at EU level

2.1.1 Introduction

The following stocktaking reviews the main actions undertaken at EU level since 2000 in support of ERA. It is not an exhaustive inventory but focuses on a selection of some of the most important ones. A more comprehensive overview is provided in the stocktaking table in annex.

Under each heading, numbered (from 1 to 7) in accordance with the 2000 Communication and (heading 8) the 2001 Communication (on the international dimension of ERA), the first lines recall the objectives listed in the original Communications. The subsequent points constitute a short description of key actions with a first summary appreciation of results achieved and limitations encountered. Community actions addressing university-based research and stemming from the work started with the 2003 Communication "The role of the Universities in the Europe of Knowledge" (COM(2003)58) are also included (heading 9).

Pertaining to action taken at EU level, this stocktaking also covers coordination of actions by Member States and mutual learning processes. Other important actions undertaken by the Member States are analysed in section 2.2.

2.1.2 Main actions, results and limitations

1. A series of material resources and facilities optimised at European level

1.1. Networking of centres of excellence and creation of virtual centres

The objective as defined in the 2000 communication was:

- To contribute to reducing the fragmentation of the European research system by combining complementary expertises and attaining a critical mass of both financial and human resources.

The main actions undertaken, results obtained and limitations encountered were as follows:

- The Sixth Framework Programme introduced new instruments and aimed at achieving critical mass of research capacity (Networks of Excellence (NoE's)) or resources from various partners (Integrated Projects (IP's)).
- Though too early for a general assessment, many NoEs correspond to 'close cooperation', thus falling short of the expected research capacity 'integration'. The overall potential impact on de-fragmentation of IPs and NoEs is limited by the very small proportion of overall research they account for.

1.2. Definition of a European approach to research facilities

The objectives as defined in the 2000 communication were:

- To develop a European approach to infrastructures covering both the creation of new installations and the functioning of/access to existing ones.
- Concerning the creation of new installations, to make an accurate assessment of future needs to be addressed at European level.

The main actions undertaken, results obtained and limitations encountered were as follows:

- 'Integrated Infrastructures' under FP6 facilitated virtual integration of 248 facilities - 40% of all existing facilities of pan-European interest.
- The European Strategy Forum for Research Infrastructures (ESFRI) adopted in 2006 the First Strategic Research Infrastructures Roadmap for Europe, which identifies 35 projects for new pan-European research infrastructures – an achievement which now needs to be acted upon.
- However, allocated FP7 resources severely limit Community support for the preparatory phase of Roadmap projects. FP7 forms of support do not correspond to infrastructure time-scales, flexibility needs and funding stability requirements. How to mobilise national, private and other sources of funding is a key question.

1.3. Maximising the potential offered by electronic networks

The objective as defined in the 2000 communication was:

- To encourage the use of electronic networks in the various fields of research, in view of increasing the productivity of European research and helping to structure collaboration on a continental scale.

The main actions undertaken, results obtained and limitations encountered were as follows:

- 'Communication Network Development' in FP6, gave rise to the pan-European launch and deployment of a series of e-Infrastructures for the research community (GÉANT, EGEE and DEISA).
- These initiatives were successful but limited budget resources hindered further deployment of grid infrastructures to many more scientific communities.

2. More consistent use of public instruments and resources

2.1. More co-ordinated implementation of national and European research programmes

The objectives as defined in the 2000 communication were:

- To implement the principle of reciprocal opening of national programmes to potential participants from other Member States.
- To put in place mechanisms for information exchange on existing national programmes.
- To encourage evaluation of national research activities by international panels.

The main actions undertaken, results obtained and limitations encountered were as follows:

- An important development under FP6 was the launch of the ERA-NET (European Research Area Network) (see also section 2.2.3 "Progress towards developing coherent European research policies") to aid national/regional managers increase mutual coherence and coordination of their respective research programmes – 30 joint calls for proposals were launched in 2006. The key to the ERA-NET is its 'bottom-up' approach, and 'variable geometry' - in terms of participating countries.
- Beyond 71 ERA-NET projects, a first pilot action under Article 169 of the EU Treaty (which covers EU participation in new integrated research programmes undertaken by several Member States) was launched - the European Developing Countries Clinical Trials Partnership (EDCTP). However, the basic conditions for a successful use of the legal instrument were not met (due to difficulties with legal/administrative rules, Member State reluctance to fully integrate their national programmes and make long-term financial commitment) seriously limiting the integration achieved. New Art. 169 initiatives under preparation aim to overcome these difficulties.
- ERA-NET and Art. 169 have enabled Member States to see better the need for optimum coordination. But despite this, the importance of these schemes in terms of volume of research funding in the overall European landscape remains limited (projects launched by end 2007 will still represent only 0.8 % of overall ERA public investments in research) and major barriers persist: a lack of national/regional strategy to differentiate programmes to open up to trans-national cooperation/coordination, from those where national autonomy should prevail; very limited progress in reciprocal or unilateral opening-up of national programmes to non-national participants outside the above mentioned schemes (see section 2.2.2 "The ERA dimension of national R&D policies").
- Other relevant developments include:
    1) Technology Platforms, which bring together industrial stakeholders to define and implement Strategic Research Agendas in specific technological fields, have an increasing coordinating effect on programmes, with impacts at EU and national levels.

2) In some sectors, co-ordination at a strategic level is ensured through specific fora (e.g. National IST RTD Directors forum[30], Standing Committee on Agricultural Research).

2.2. Closer relations between European organisations for science and technology cooperation

This subject is treated under Section 2.2.2 "The ERA dimension of national R&D policies".

3. More dynamic private investment *(see also Chapter 3, section 3.2.2)*

3.1. Better use of instruments of indirect support for research

The objectives as defined in the 2000 communication were:

- To encourage the exchange of information and spread of good practices on mechanisms aiming to stimulate private investment in research, particularly among small and medium sized enterprises (SME's), and innovation.
- To respect Community State aid rules where measures constitute State aid.

The main actions undertaken, results obtained and limitations encountered were as follows:

- R&D fiscal measures are more common in EU Member States now than in 2000. Best practices in fiscal measures to stimulate R&D were identified and shared among Member States in the framework of CREST (Scientific and Technical Research Committee) working groups. In 2006 the Commission adopted a Communication 'Towards a More Effective Use of Tax Incentives in Favour of R&D' with a staff working document offering guidance for the design and implementation of R&D tax incentives. Next steps will focus on the lack of consistent evaluation studies of national R&D tax incentives.
- On State aid issues, the adoption by the Commission in 2006 of a new Community Framework for State aid for R&D&I, is a key development.

3.2. Development of effective tools for the protection of intellectual property (IP)

The objectives as defined in the 2000 communication were:

- To adopt the European (Community) patent as soon as possible. It must be readily affordable and comparable in cost to a European patent covering a limited number of countries.
- To assess how the effects of disclosures prior to filing can be taken into account by European patent law (issue of 'grace period').
- To improve the relevance and consistency of the intellectual property arrangements used to implement public research programmes.

The main actions undertaken, results obtained and limitations encountered were as follows:

- There has been no major breakthrough in this area. IP protection remains too complicated and costly in Europe for patents and litigation. Community patent

[30] The National IST RTD Directors forum is an informal forum of national and European decision-makers. It meets to discuss and develop shared visions and strategies for ICT RTD in Europe, to share knowledge and best practice, and to improve coordination in ICT RTD in Europe.

negotiations are stuck in Council. The March 2003 political agreement would only lead to 20-30% savings compared to the current European patent.

- In the context of an international harmonisation, at the end of 2002 the EU Member States agreed a common position on grace period based on a "safety net approach" and that was expressed at the 2003 WIPO Standing Committee on the Law of Patent. However, negotiation of the new international treaty (SPLT[31]) which would provide such international harmonisation has been also stuck since April 2006. Furthermore, parallel negations among industrialised countries (Group B+) go slowly.
- A new Commission communication on an 'EU patent strategy' is in preparation. It will encourage progress regarding the Community patent, and support the creation of a European patent judiciary hearing patent infringement and invalidity action.

3.3. Encouragement of risk capital investment and company start-ups

The objectives as defined in the 2000 communication were:

- To step up initiatives to provide innovative start-up companies with the technical support and expertise they need to develop.
- To encourage initiatives to bring scientists, industrialists and financiers at all levels into contact.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Three developments can be noted:
    1) Adoption by the Commission of Guidelines on State Aid for Risk Capital in 2001 and, following a review of the text, in 2006;
    2) Direct investment into venture capital funds targeting young innovative firms;
    3) Adoption of the Competitiveness and Innovation Programme (CIP) which includes increased Community support (managed by the European Investment Fund (EIF)) and awareness–raising actions targeted at potential recipient companies.
- Statistical comparisons with the US still paint a bleak picture for the EU where supply and demand side barriers hamper efficient deployment of risk capital and where the Single Market does not operate well - different regulatory and tax environments reinforce fragmentation and inhibit cross-border operations.

4. A Common system of scientific and technical reference for policy implementation

4.1. Development of the research needed for political decision-making

and

4.2. Establishment of a common system of scientific and technical references

The objectives as defined in the 2000 communication were:

[31] Substantive Patent Law Treaty being under negotiation in WIPO since May 2001

- To systematically exploit the results of research undertaken as part of European programmes in support of the various Union policies and to better co-ordinate all the Union's research activities in this respect.
- To put in place a reliable system of validating knowledge and methods of analysis, control and certification and to network centres of excellence in Europe in the field concerned.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Of the numerous actions in this area, two key ones were:
  1) Adoption by the Commission in 2002 of guidelines and principles on the collection and use of expertise by the Commission services;
  2) Development of the SINAPSE[32] web communication platform.
- Diversity and inconsistencies in the systems of scientific advice provision in Europe remains a major challenge.
- Logistic support to scientific advice systems and activities via SINAPSE needs both time and resources to be fully developed. The resources dedicated to date have not been commensurate with the task.

5. More abundant and mobile human resources

5.1. Greater mobility of researchers in Europe,

5.2. Introduction of a European dimension into scientific careers

and

6.3. Making Europe attractive to researchers from the rest of the world

The objectives as defined in the 2000 communication were:

- To encourage and develop both geographical mobility (notably through proper valuation of experiences elsewhere in Europe in the frame of career assessment) and inter-sector mobility of researchers (i.e. between the academic world and the business world, as an instrument of technology transfer).
- To attract the best researchers from all over the world, as well as to encourage the return to Europe of researchers who have left Europe, in particular for the United States.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Two important achievements in this area were:
  1) The Recommendation on the European Charter for Researchers and Code of Conduct for their Recruitment - a landmark instrument for raising awareness and improving researcher career management;
  2) The adoption of the 'scientific visa' package (a Directive and two Recommendations on the admission and residence of third country nationals to carry out research in the EU October 2005).

[32] SINAPSE is a web communication platform, being developed by the Commission, in order to promote a more efficient use of scientific information and expertise in support of policy making.

- Practical-assistance tools for researchers have also been developed, e.g. the Pan-European Researchers Mobility Portal and the European Network of Mobility Centres (ERA-MORE).
- Overall achievements since 2000 remain marginal compared to the importance of what is at stake (see Chapter 3, section 3.2.3). The central issue remains employers' tendencies to recruit and promote researchers from their local environment without open and transparent procedures. Also, the regulatory frameworks in place fail to recognize researchers as a specific population with specific needs, and fail to eliminate regulatory obstacles to career development and mobility, e.g. in social security and taxation.

5.3. A greater place and role for women in research

and

5.4. Giving young people a taste for research and careers in science

The objectives as defined in the 2000 communication were:

- In the area of gender balance, to stimulate exchanges of experience among the Member States and to develop a coherent approach towards promoting women in European funded research with the aim of significantly increasing the number of women involved in research.
- To study how the teaching of sciences in the Union can be improved at all levels of education, and to create conditions conducive to the sharing of experiences and good practices.

The main actions undertaken, results obtained and limitations encountered were as follows:

- In both areas, cross-country comparisons, identification/development of best practices and their dissemination have been carried out through many initiatives. The 'Gender Action Plan' (GAP) was a key FP6 initiative to promote gender equality within projects.
- Important bottlenecks persist:
    1) Mental barriers regarding gender balance: scientists often perceive that measures to increase the participation of women are not compatible with scientific excellence;
    2) In the area of sciences teaching, delays - or even blockages - in transferring innovative methods from the proof-of-concept stage to the classroom.

6. A dynamic European landscape, open and attractive to researchers and investment

6.1. A Greater role of the regions in the European research effort

and

6.2. Integration of the scientific communities of Western and Eastern Europe

The objectives as defined in the 2000 communication were:

- To negotiate on the structural assistance planned for the years 2000 to 2006 in order to examine how best to combine projects implemented within this framework with projects undertaken in the European programmes.
- To put in place the conditions for research policies adapted to the socio-economic context of a regional territory and to strengthen the role that regions can play in establishing a more dynamic ERA.

The main actions undertaken, results obtained and limitations encountered were as follows:

- € 10.6 billion of cohesion policy funding, notably from the European Regional Development Fund, is estimated to be used to support R&D and innovation in the 2000-2006 programming period. This investment plays a significant role in fostering research and innovation activity, particularly in the Community's less developed Member States and regions, especially when the national, regional and private co-financing leveraged by cohesion policy programmes is also taken into account. Cohesion policy programmes offer a platform for regional stakeholders to increase their capacity to undertake excellent research and exploit its results. They are the EU's main instrument for fostering research activity in less developed Member States and regions and thus help to address the lack of cohesion and S&T development gaps identified as a problem in the ERA Communication of 2000. The Community Strategic Guidelines on economic, social and territorial cohesion 2007-2013 give an even more prominent place to R&D and innovation as a driver of economic growth.

- The Commission has tried to create a framework for co-ordination of cohesion and research policy with the proposals for cohesion policy programmes and the 7th RTD Framework Programme for 2007-2013. However, the different levels of governance mean that national and regional stakeholders are in practice responsible for co-ordinated use of the two instruments and for co-ordination of projects. A report on "How to achieve better co-ordinated use of the EU Structural Funds and the 7th Research Framework Programme to support R&D" will be delivered in early 2007 in the framework of the CREST mutual learning process between Member States.
- Through its "innovative actions" programmes, cohesion policy has also supported the development of regional strategies in less favoured regions on the theme of knowledge-based technological innovation. Such strategies help regional stakeholders in less favoured regions to implement measures appropriate to their specific context.
- The regional dimension of the European research effort is also acknowledged in the RTD Framework Programme. Positive results of the 'Regions of Knowledge' initiative launched in 2003 to promote more and better investment in research through mutual learning, coordination and collaboration among regional players has led to an extended 'Regions of Knowledge' activity in FP7. In addition, the new FP7 'Research Potential' action will focus explicitly on strengthening research capacity in 'convergence regions' and 'outermost regions' in terms of physical and human capital.

6.3. Making Europe attractive to researchers from the rest of the world: See 5.1., 5.2

7. Area of shared values

7.1. Tackling science/society issues on a European scale

The objective as defined in the 2000 communication was:

- To encourage the development of new and sustained forms of dialogue between researchers and other social operators/civil society organisations, notably through the organisation of 'Citizens' Conferences' at European level.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Initiatives in this field developed mainly on two fronts:
  1) Identification and dissemination of best practices (e.g. the Commission's 2001 Science and Society Action Plan, or the European platform of stakeholders and experts in participative techniques - (CIPAST) Citizens Participation in Science and Technology);
  2) Concrete implementation of participative techniques (e.g. two full-size 'Consensus Conferences', or a new FP7 instrument to support the participation of civil society organisations).
- Development in this area is still embryonic - e.g. the open-coordination process begun in 2001 has been far from successful, as no counterpart to the Commission's Science and Society activity exists in some Member States.

The objectives as defined in the 2000 communication were also:

- To develop more consistency in foresight exercises at national and European level and within the framework of the numerous existing networks.
- To establish a platform for exchange, to create points of synthesis and to align methodologies.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Progress has mainly been made on the identification and dissemination of best practices. For this purpose, an online guide has been developed to serve as a reference system for Foresight[33] (trans-national networks, mutual learning workshops for both policy-makers and foresight practitioners in Member States, development of tools, particularly for regions wishing to launch foresight initiatives). A monitoring system on foresight in Europe (EFMN), with a web portal (www.efmn.info) has also been set up. Exchange of knowledge and practice between Foresight practitioners and policy- makers was facilitated through several measures. [34]
- However, foresight has not yet reached a reasonable state of integration and coherence at EU level. Furthermore, direct impact of foresight on S&T decision making in the Member States and in the Commission cannot easily be identified – impact is mostly indirect.

7.2. Development of a shared vision of ethical issues in science and of technology

The objectives as defined in the 2000 communication were:

- To strengthen the links between the ethics committees established at national and European levels.

[33] http://forlearn.jrc.es/guide/0_home/index.htm
[34] European Foresight Monitoring Network

- To encourage the opening up of the various national committees to experts from other European countries in view of helping to make for mutual understanding of points of view and the development of harmonious approaches.
- To compare the rules in force and the criteria on ethics used in national and European research programmes with a view to alignment around shared principles and respect for differences in sensitivities and opinions.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Actions undertaken have helped to foster dialogue and learning especially for Member States with weak institutional infrastructure for addressing ethical issues. They included mapping of existing rules, exchange of information, experience and best practices in the form of both punctual (conferences, studies, workshops) and structural (creation of the National Ethics Councils (NEC) Forum in 2003, the European Network of Research Ethics Committees (EUREC) in 2005 and an electronic database of opinions of national councils) initiatives.
- However, the objective of a 'shared vision of ethical issues' is clearly a remote one, as ethics is deeply embodied in national cultures, and on a number of issues opinions diverge significantly.

8. Develop an ambitious and extensive international S&T co-operation programme[35]

The objective as defined in the 2001 communication was:

- To open the European Research Area to the rest of the world.

The main actions undertaken, results obtained and limitations encountered were as follows:

- The EU has increasingly encouraged participation by third countries in its research programmes and concluded S&T agreements with many third countries.
- However, the impact of these agreements remains relatively limited, except when focussed on cooperation in specific areas (e.g. nanotechnologies with the US). S&T agreement reciprocity clauses give researchers on both sides access to each other's research funding. However, in the absence at present, of a mechanism to fund European participation, full use of reciprocity and real access for Europeans to third country research funds remains elusive.

The objectives as defined in the 2001 communication were also:

- To focus EU efforts on specific objectives
- To step up international 'technology watch' activities.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Research capabilities in partner regions have been strengthened via the Specific International Scientific Cooperation Activities (INCO) Programme, though at an insufficient level to have longer-term and larger-scale institutional effects. [36]

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[35] Objectives and actions as defined in COM(2001)346 'The international dimension of the European Research Area'

[36] Mutually beneficial international cooperation activities between the Community and its Member States and INCO target countries and other third countries

- No mechanism exists to determine horizontal international co-operation priorities across and between thematic areas of the Framework Programme.
- S&T co-operation actions by the Member States with third countries is un-coordinated, despite some first steps in this direction - e.g. some ERA-NETs (see point 2.1) focus on international co-operation of EU Member States with some regions; a CREST working group aims to produce an inventory of international S&T co-operation activities conducted by Member States.
- Technology platforms, with some exceptions such as the Global Animal Health technology platforms, have not considered international co-operation in great depth in their Strategic Research Agendas.

The objectives as defined in the 2001 communication were also:

- To align EU scientific co-operation policies with EU foreign policy and development aid programmes.

The main actions undertaken, results obtained and limitations encountered were as follows:

- Cross references are made to the importance of research actions in relevant EU external policy initiatives. However, ensuring coherence is dealt with on an ad hoc basis - no mechanism currently exists with which to maintain an overview and assessment of the coherence of potential external policy actions with international research co-operation.

The objectives as defined in the 2001 communication were also:

- To enlist EU scientific and technological capabilities to deal with world problems.

The main actions undertaken, results obtained and limitations encountered were as follows:

- The conclusion of the ITER agreement, which brings together the EU, Japan, China, India, Korea, Russia and the US, and which places Europe at the forefront of nuclear fusion research. Many examples of EU response to global problems can be found in the Framework Programme – e.g. in relation to health.
- However no mechanism outside the Framework programme exists to jointly identify which global issues are appropriate for an EU response or how such a response could be organised.

9. As regards Community actions addressing university-based research

Besides the areas addressed in the 2000 ERA Communication, there have also been Community actions addressing university-based research, stemming from the work started with the 2003 Communication "The role of the Universities in the Europe of Knowledge":

9.1 Concerning Member States:

With due consideration for the fact that the main actors are situated at national and regional levels or in the universities themselves, the EU is engaged in the coordination of actions with public authorities to support the Modernisation of European university-based research. This includes several domains such as:

- The granting of real autonomy and accountability to universities,
- The funding of university-based research more on the basis of academic and non-academic research outputs (industrial and/or international partnerships),

- The promotion of professional management in universities and the development of needed research management tools (such as transparent research accounting systems),
- The support of their innovation capacities.

9.2 Concerning universities:

Through European-wide stakeholders, the EU is also working with the institutions themselves to support the Modernisation of European university-based research on the above mentioned domains where work with the public authorities is being pursued.

Through an increased budget and a range of new actions, the 7th Framework Programme (FP7) represents a major new step in the Community policy to enhance university based research, including:

- Increased EU funding for research performed by higher education institutions from 50% to 75% of total eligible project costs and to allowing funding on the basis of full economic cost;
- The establishment of the European Research Council, supporting 'frontier' research and stimulating excellence through competition, will concentrate funding on top European performers. Universities will be able to receive up to 100% of eligible research costs;
- Enhanced support to the establishments of structured links between universities and non-academia, through several FP7 instruments: intersectoral mobility in Marie Curie actions, science shops, regions of knowledge; research driven clusters.

9.3 Concerning general support of policy in this domain:

Support to collecting and producing of data on research and education in universities

2.1.3 Appraisal

Two major conclusions can be drawn: 1) progress towards the objectives is varied, and 2) in areas where progress has been made, the impact on the European research system remains limited. In other words, progress so far constitutes only the first steps on the way to making ERA a reality.

One of the notable developments has been the launch of the ERA-NET scheme.[37] This has allowed managers of some national programmes to begin to make an important contribution to the building of ERA by looking at ways and taking action to reduce inefficiency and fragmentation inherent to a system made up of numerous national research funding schemes. The figures in the stocktaking quantifying the response thus far, suggest that ERA NET responds to a real need. In addition to ERA-NETs, other initiatives with an impact on fragmentation such as 'Article 169' initiatives, and European Technology Platforms continue to develop.

Another area where good progress has been made is research infrastructures. Pan-European infrastructures must play a key role in reinforcing overall European research capacity. A striking example of how more can be done is in the area of health research where the development of a pan-European network of bio-banks representing the diversity of the European population would provide vastly increased analytical power. In several research

[37] See ERA-net review 2006, The report of the Expert Review Group, December 20O6

fields, the situation is simply that no single Member State can afford to develop the required infrastructures.

Building on the widespread consensus that emerged following the 2000 ERA Communication on the need to forge a more co-ordinated European approach to key research infrastructures, a first major milestone was reached with the adoption in 2006 of the European Strategy Forum for Research Infrastructures (ESFRI) Roadmap. But the Roadmap will only be a success if the proposed projects are built. For this to happen there is still a long way to go: New approaches are required - new legal, institutional and financial tools need to be developed.

In short, progress thus far in these two areas (coordination of national programmes and infrastructures), demonstrates that the initiatives corresponded to a demand – latent or explicit. But, above all, it underlines the need for new initiatives with more impact, especially at the strategic/governance level.

The same can be said in the areas of 'science & society', where participative techniques (for civil society to take an active part in policy-shaping and decision-shaping discussions concerning science) and strategic foresight need to be deployed in ERA at a higher scale. In the area of international cooperation, success stories such as ITER show that Europe has the will and the capacity for leadership to address global challenge with partners around the world. But, while Europe is increasingly engaged in global science, research and infrastructure initiatives, these initiatives are far from systematic and often poorly coordinated with those of the Member States.

In some other areas, despite the efforts made, progress achieved has been even more limited.

This is the case for instance for the labour market for researchers. Human resources in science and technology (S&T) are a key strength of Europe, where more S&T PhDs are produced than in the US. But, as Europe crucially lacks an open, competitive and attractive labour market for researchers, the exploitation of this strength is sub-optimal and Europe instead suffers from wasted resources: some bright researchers and S&T graduates leave, others do not enter a research career in Europe or exit early, others miss opportunities to move into positions where their capacities could be better used and developed. The instruments used up to now in these areas, and the up-take of specially-developed ones by Member States, are not commensurate with the importance of this challenge (see Chapter 3, Section 3.2.3).

A second problematic area is private investments in research. The latest statistics available do not show any increase whatsoever in business-funded research intensity of the EU compared to 2000. The gap between the EU and its major competitor has not reduced - in fact; quite the contrary (see Chapter 3, Section 3.3.1). Compared to what was announced in the 2000 ERA Communication, the range of actions related to the objective of stimulating private investments in research and development (R&D) was broadened considerably, in the wake of the Barcelona summit of 2002 and the 3% Action Plan. Of course, for many of these initiatives, it is too early to see their potential impact on the statistics. This is the case for the new impetus given by the re-launch of the Lisbon strategy in 2005, with, in particular, the many actions taken in the framework of the National Reform Programmes. If, on one hand, a lot depends on the implementation by the Member States of their National Reform Programmes, ERA-level actions also have a key role to play to achieve the Barcelona targets. In particular, the globalisation of R&D stresses the need to create European poles of excellence capable of attracting internationally mobile R&D private investments (see Chapter 3, section 3.3.1).

2.1.4 Highlights

- ✓ Actions undertaken at EU level since 2000 in support of ERA have delivered modest and varied progress with limited impact at the overall European research system level.
- ✓ Efforts to coordinate national programmes and infrastructures confirm that there is a demand (latent or explicit) but show that corresponding initiatives should have a higher ambition at the strategic/governance level.
- ✓ In some areas such as fostering greater researcher mobility and dynamic private investments, progress achieved has been even more limited.

2.2 Stocktaking of national policies contribution to the ERA

2.2.1. Evolution of national policy mixes for R&D

National policies for R&D over the past decade have evolved significantly towards more coherent, richer, but also more complex policy mixes. In their policies, Member States are increasingly taking a multi-annual and strategic approach to R&D, offering a stable and predictable environment to an endeavour which is inherently long term in nature. Moreover, although policy mixes are still largely geared towards R&D specific policy instruments, the attention has in recent years shifted towards broader approaches by including and integrating from other policy domains (such as e.g. innovation, education, fiscal, competition, IPR, …), having a direct or indirect impact on R&D activity.

Further strengthening of R&D policy as part of a reform agenda geared towards more growth and jobs has been achieved through the revision of the Lisbon strategy in 2005. Following that, all Member States have in their National Reform Programmes now established targets for R&D expenditure, tailored to their specific situations (see Figure 2.1), which, if they were met, would in 2010 lead to an EU R&D intensity of 2.6% gross domestic product (see section 3.3.1 on R&D expenditure and financing for a discussion on progress towards the 3% target). Recently, however, in the context of the Commission's Annual Progress Report on the revised Lisbon strategy, it was noted that, although several Member States have announced their intention to prioritise public R&D expenditures, several have not yet made the necessary budgetary commitments and that for some Member States further policy initiatives will be needed to advance significantly towards their R&D spending targets.[38]

R&D strategies

A large majority of Member States now have specific strategies in place for stimulating both the quantity and quality of R&D activity. Common elements of those strategies are their long term character and a strategic view based on identifying bottlenecks, formulating challenges and matching the portfolio of policy instruments to address those challenges.

The scope of Member State strategies varies, with some focussing on R&D (e.g. France: Pact for Research, Netherlands: Science Budget 2004 – Focus on excellence and greater value, Czech Republic: National Research and Development Policy of the Czech Republic for 2004-2008), others tackling R&D and broader innovation aspects in an integrated manner (e.g. UK: Science and Innovation Investment Framework 2004-2014, Ireland: Strategy for science, technology and innovation 2006-2013, Spain: Ingenio 2010, Sweden: Innovative Sweden – A strategy for growth through renewal) and a limited number that put R&D and innovation under an overarching umbrella (e.g. Denmark: Progress, Innovation and Cohesion: Strategy for Denmark in the Global Economy;).

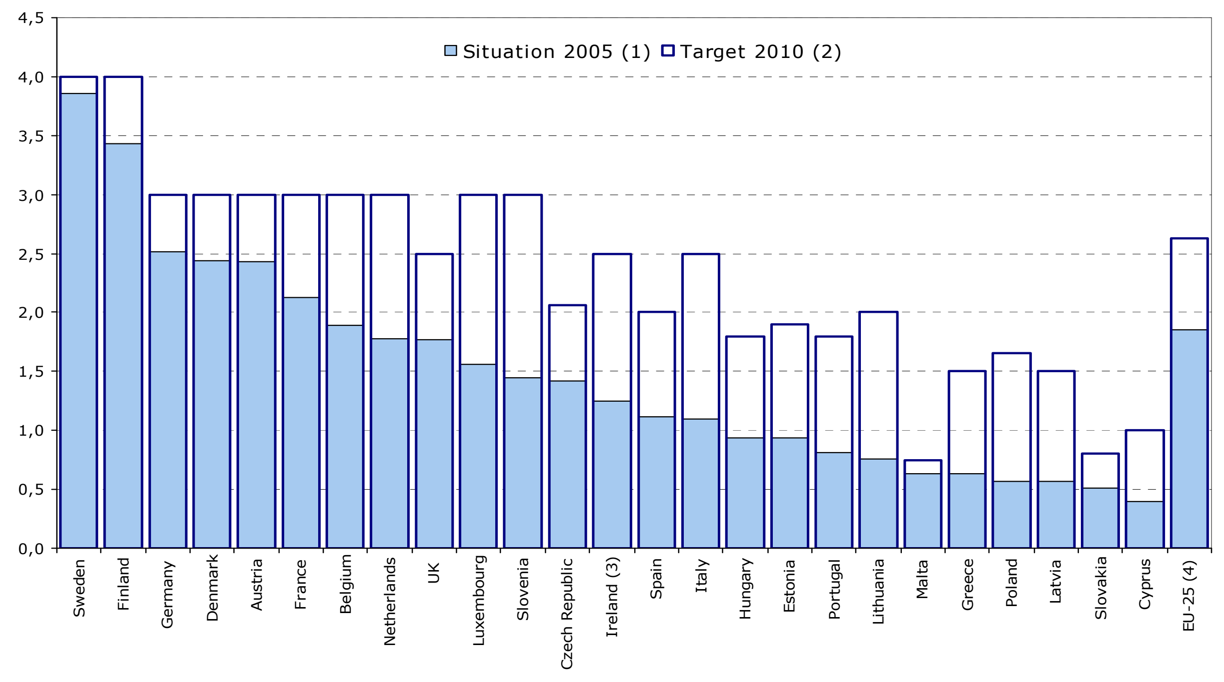
In some Member States, due to specific divisions of competence between policy levels, strategies are primarily developed at the regional level (e.g. Belgium: Flanders in action. A socio-economic stimulus for Flanders). More in general, a large and increasing number of EU regions have now developed R&D strategies to complement national policies.

In their national policies, Member States generally recognise policy developments at the European level as factors that are to be taken into account in national policy making, with

[38] COM(2006) 816, 'Communication from the Commission to the Spring European Council – Implementing the renewed Lisbon strategy for Growth and Jobs – A year of delivery' – Annex 'Macro-economic, micro-economic and employment issues'

reference being made most often to the general objectives of the Lisbon strategy and the 3% objective.

Figure 2.1: R&D Intensity (Gross domestic expenditure on R&D (GERD) as % of GDP)



Notes:
(1) Greece: 2003; Belgium, Italy, Malta, Netherlands, Slovenia, UK: 2004. (2) Portugal: 2008; Ireland: 2013; UK; 2014. (3) Ireland: The target is 2.50% of gross national product in 2013.(4) EU-25: The EU-25 R&D intensity for 2005 was estimated by DG Research. EU-25: The EU-25 R&D intensity for 2010 results from the aggregation of the set targets set by the Member States (including estimated targets for Ireland, Portugal and the UK). (5) Member States have been ranked according to the current level of R&D intensity from left to the right.

Source: Eurostat, Member States

There are increasing indications that policy debates at Community level are having an effect on the way in which Member States are constructing their national policy mixes.[39] The overall view that emerges is that there is a degree of similarity and convergence appearing in national R&D policies throughout the EU in that Member State authorities have subscribed to a number of similar objectives and challenges, in line with the issues addressed in the revised Lisbon strategy's Integrated Guidelines, and are, explicitly or implicitly, taking guidance from discussions at the European level (such as through the Open Method of Coordination (OMC) or through Commission Communications) or through the identification and transfer of good practices identified in other Member States.[40]

Public funding of research activity continues to be a dominant element of national policy mixes, though the evolution has been to move towards a wider range of funding schemes, going beyond the traditional elements of institutional funding of public research institutes and subsidies for project based research and now including e.g. loan and guarantee schemes, equity, fiscal incentives, and instruments such as procurement (of R&D services notably).

Fiscal incentives for R&D have been a subject of intense discussion at the European level. A CREST OMC expert group has addressed the issue and the Commission published a

[39] Jakob Edler, Stefan Kuhlmann, 'Towards one system? The European Research Area initiative, the integration of research systems and the changing leeway of national policies', Technikfolgenabschätzung – Theorie und Praxis, 2005, 14, 1, 59-68

[40] Council Recommendation on the Broad Guidelines for the Economic Policies of the MS and the EC (2005)

Communication on the subject in December 2006.[41,42,43] The number of Member States implementing some form of fiscal incentives for R&D has been rising continuously and now stands at 17, with others still holding the subject under consideration. In parallel, evidence is emerging that the generosity of fiscal incentives (as a tool for public financing of business R&D expenditure) has significantly increased since 2000.[44]

Trends in fiscal incentives for R&D

Public financial support to private investments in R&D comes in either of two forms:

- Direct funding of a part of the targeted expenditures (subsidy).
- Fiscal incentives allowing companies to reduce their tax payments.

Although the balance between both policy tools differs significantly between Member States, an analysis at EU level leads to some important findings:

- In the EU, the past 15 years, and in particular the past 5 years, witnessed a significant shift in balance from direct subsidies towards fiscal incentives.
- The increase in generosity of fiscal incentives after 2000 did not happen at the expense of direct subsidies.
- Even though there is no convergence towards one optimum level of fiscal treatment of R&D across EU countries, many national governments nevertheless have recognised the importance of fiscal incentives for R&D as a complement to direct subsidies.
- By 2006, the generosity of the R&D tax treatment in the EU had slightly exceeded that of the US, even though the US still provides higher direct subsidies for business R&D.

Public research organisations, mainly universities in many countries, are throughout the EU the main performers of basic research. The organisation of universities and the contribution they can make to the Lisbon goals has been the subject of two Communications by the Commission.[45,46] Many Member States have in turn reconsidered the way in which their public research system is structured and are in this respect addressing similar issues such as giving more autonomy to public research organisations, a strengthening of the third mission of universities, strengthening the links between universities and the private sector or the organisation of funding, with competitive funding streams gaining importance.

Technology transfer from public research institutions to the private sector has been at the heart of the European policy debate for a number of years. It is one of the issues that have been discussed at length during the first and second OMC cycles and is a subject where the Commission has announced that it will provide its views and guidance in the near future. [47,48]

[41] Expert Group on Fiscal Measures for Research, CREST Report (June 2004)
[42] Evaluation and design of R&D tax incentives, OMC CREST Working Group, 17th March 2006
[43] COM (2006) 728 'Towards a more effective use of tax incentives in favour of R&D'
[44] 'Evolution of EU Direct subsidy – Fiscal incentives Policy Mix, Report prepared for European Commission – DG Research, Jacek Warda, JPW Innovation Associates Inc (January 2007)
[45] COM (2006) 208 'Delivering on the modernisation agenda for universities : education, research and innovation'
[46] COM (2005) 152 'Mobilising the brainpower of Europe: enabling universities to make their full contribution to the Lisbon strategy'
[47] Report of the CREST Expert Group on The Public Research Base and its Links with Industry, Final report , June 2004
[48] Report of the CREST Expert Group on: Encourage the reform of public research centres and universities, in particular to promote transfer of knowledge to society and industry, Final report, March 2006

At the same time, Member States are closely scrutinising the way in which their public research efforts get transformed into economic and broader societal benefits.[49]

Although this is clearly an issue shared amongst all Member States, there is considerable variety in the way in which they address it through measures such as collaborative research programmes, networking and clustering schemes, measures to stimulate circulation of researchers between the public and private sectors, establishing technology transfer offices at universities or more recently the setting up of durable and long term public private partnerships.

Public-private partnerships for R&D

Whereas 'technology-push'-type policy measures were typically the instrument of choice in addressing the European innovation paradox, the establishment of public-private partnerships for R&D aims at creating a dynamic of open innovation in which the main rationale is two-way knowledge circulation and a matching of business needs and research expertise.

There is a wealth of policy measures in place across Member States to promote the building of long-lasting and strategic partnerships between the public and private sectors. Such partnerships can take a number of forms:

- Joint research centres, e.g. Austria: Christian Doppler Laboratories; Netherlands: Leading Technological Initiatives; Belgium: some of the Flemish' region's competence poles.
- Long term cooperation agreements having a sectoral or thematic focus, e.g. France: competitiveness poles; Belgium: competitiveness poles; Estonia: competence centre programme; Hungary: cooperative research centres; Ireland: centres for science, engineering and technology; Italy – Technological districts.
- Networking and clustering schemes, e.g. Czech Republic: national cluster strategy – KLASTRY, Denmark: High Tech networks, UK: Knowledge Transfer Networks.
- Large scale, long term collaborative R&D, e.g. France: Agency for Industrial Innovation, Spain: CENIT – National strategic consortia for technical research.
- The establishment of national technology platforms (along the model of the European Technology Platforms), e.g. national technological platforms in construction (Austria, Belgium, Denmark, Germany, Greece, Italy, Netherlands, Portugal, Slovenia, Spain), Poland: Polish Technology Platforms, UK: Innovation Platforms, Italy: national Technology Platforms.

Through the establishment of public-private partnerships, R&D policy makers are increasingly stimulating their public research organisations to take into account the strategic needs of the economy and at the same time are creating incentives within their businesses to articulate their needs and draw upon the public research base in support of their innovation processes.

Human resources and mobility actions have long been an important element of Community R&D policy and it is a policy area where the Commission has gone beyond funding by e.g. developing the Charter for researchers and the Code of conduct for the recruitment of researchers or by proposing a Council directive (alongside two Council recommendations) facilitating the entry of third country researchers into the EU.[50,51] Member States are equally aware of the fact that a sufficient supply of qualified researchers is crucial for the development of their R&D systems. All Member States are taking action in this area by developing measures aimed at improving e.g. the attractiveness of research careers,

[49] E.g. France: *Rapport sur la valorisation de la recherche (Inspection générale des finances, Inspection générale de l'administration de l'éducation nationale et de la recherche*, January 2007), UK: Knowledge transfer in the eight research councils – 'Independent External Challenge Report to Research Councils UK', April 2006.

[50] Commission Recommendation of 11/03/2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers.

[51] COM (2004) 178 'Communication from the Commission to the Council and the European Parliament on the presentation of a proposal for a directive and two proposals for recommendations on the admission of third-country nationals to carry out scientific research in the European Community'.

stimulating the circulation of researchers between the public and private sectors or attracting foreign and expatriate researchers.

2.2.2. The ERA dimension in national R&D policies

It is undeniable that the introduction of the concept of a European Research Area in 2000, as the contribution of research policy to the broader Lisbon strategy, has been successful in putting research higher on the political agenda.

In contrast to this, however, ERA is only to a limited extent acknowledged as a factor in its own right and explicit mention of it is scarce, revealing a situation in which Member States contribute mainly towards developing the ERA by strengthening their national R&D capacity, the ultimate goal being a national system in itself excellent on an international scale. National strategies very rarely discuss the issue of national efforts towards common European goals and even if intra-European aspects are indicated (with mainly some of the smaller Member States developing their strategies in view of an overarching European perspective), they are most often only minor elements of the overall strategy.

Member States do recognise the importance of offering their researchers the possibility to engage in cross border collaborations and are therefore supportive of high levels of national participation in international R&D programmes. Frequent mention is made of the need to participate strongly in the Framework Programme and measures aimed at stimulating, directly (e.g. financial support for preparation applications, co-funding of successful participants) or indirectly (e.g. through strengthening centres of excellence, imitation of Framework Programme thematic priorities, establishment of national Technology Platforms or building critical mass), the participation of their own nationals in the Framework Programme are often noted.

Some Member States have gone one step further and have introduced the (partial) unilateral opening up of their national research systems as part of their overall strategy, inspired by the view that knowledge spill-over's from abroad can add to the existing R&D capacity, that this can increase its quality through increased competition or can give access to fields in which national capacity is limited. A study carried out on behalf of the European Commission made a number of interesting observations in this respect, leading to the conclusion that opening up is still a relatively minor part of national policy: [52]

- ✓ The funding of trans-national research projects is most commonly observed as an element of opening up. Although a majority (60%) of the programmes surveyed in the study reported having funded trans-national projects, the actual spend on trans-national activities remains marginal, the majority of programmes remaining below 5% of total budget.
- ✓ Only a small proportion (16%) of programmes report having contributed to multilateral programmes with a central budget.
- ✓ Around two thirds of surveyed programmes allow participation of non-resident researchers from other EU countries. Only 23%, however, have actually paid for the

[52] 'Examining the design of national research programmes', December 2005, Optimat Ltd – VDI/VDE-*Innovation + Technik GmbH*

participation of foreign partners and an even smaller number (16%) state that foreign participation is actively encouraged.

Bi- and multilateral cooperation between Member States, driven in part by the ERA-NET (European Research Area Network) instrument which was introduced in FP6, are also apparent in many national policies, although more often than not cooperation is restricted to specific research domains or to specific projects, such as the construction of a joint research facility (e.g. Spain and Portugal committed to jointly construct an international centre of excellence in nanotechnology; the facility is planned to be operational in 2008 and will gather 200 researchers and 200 other staff members, operating a yearly budget of € 30 million). Strategic approaches to cooperation amongst groups of Member States are scarce, with some notable exceptions such as the Nordic Council of Ministers, the French-German or the Dutch-Belgian cooperation initiatives.

The case of the Nordic Council of Ministers

The Nordic Council of Ministers, established in 1971, is a forum for governmental cooperation between the Nordic countries (Denmark, Finland, Sweden, Norway, and Iceland including the autonomous territories Faroe Islands, Greenland and Aland). Cooperation extends across a wide range of policy areas, including research. The Nordic Research Board (NordForsk) was established in 2005 to coordinate Nordic research. Activities include the funding of research projects, grant schemes, Nordic Centres of Excellence and the coordination and planning of major infrastructure investments.

The intergovernmental organisations for European scientific and technological cooperation ESF (European Science Foundation), ESA (European Space Agency), EMBO (European Molecular Biology Organisation), EMBL (European Molecular Biology Laboratory), CERN (*l'Organisation Européenne pour la Recherche Nucléaire)*, ESO (European Southern Observatory), ESRF (European Synchrotron Radiation Facility), ILL(Institut Laue-Langevin)[53], EUREKA,[54] and COST (European Cooperation in the field of Scientific and Technical Research) have an important role to play in helping construct the ERA as they together represent some 9% of total public expenditure on R&D in Europe and offer European researchers both top notch research infrastructures and worthwhile instruments for trans-national networking and collaboration.[55] As members of those organisations, Member States recognise their importance and make frequent mention of them in policy documents. A recurring point of discussion in recent years has been an increasing call from Member States to coordinate the instruments available at the European level, notably through establishing cooperation and synergies with the Community's Framework Programme. Concrete actions as a result of this include:

- ✓ Direct funding of COST through FP6, which is being continued throughout FP7.
- ✓ The involvement of two EUREKA clusters in the preparation of two candidate Joint Technology Initiatives (nano-electronics, embedded computing systems).

[53] Institut Laue-Langevin is an international research centre at the leading edge of neutron science and technology.

[54] EUREKA is a pan-European network for market-oriented, industrial R&D. EUREKA supports the competitiveness of European companies through international collaboration, in creating links and networks of innovation.

[55] SEC(2005) 430, 'Annex to the proposals for Council and European Parliament decisions on the 7th Framework Programme: Impact assessment and *ex ante* evaluation'

- ✓ The active involvement of EUREKA in the preparation of EUROSTARS, one of the candidates for new initiatives under Article 169 of the EU Treaty, aimed at highly innovative small and medium sized enterprises (SME's). [56,57]
- ✓ The conclusion of a Framework Agreement between the Community and ESA, the establishment of a joint secretariat and the subsequent ongoing development of a European space policy, including a strong Community dimension.
- ✓ In 2002, CERN (*l'Organisation Européenne pour la Recherche Nucléaire)*, ESA (European Space Agency), EMBL (European Molecular Biology Laboratory), ESO (European Southern Observatory), ESRF (European Synchrotron Radiation Facility), ILL (Institut Laue-Langevin) and EFDA (European Fusion Development Agreement) together formed the EIROForum partnership aiming to pursue joint initiatives, combine resources and share best practices. [58,59]

Although definite advances have been made in establishing coordination between the different European organisations for scientific and technological cooperation, including the Community instruments, experience has shown that, due to their different nature (including variability in membership) and ways of operation, establishing links and exploiting synergies has not always been a simple task. In particular as regards the establishment of close links between the Framework Programme and EUREKA, negotiations in preparation of concrete proposals for FP7 have shown that EUREKA member countries have been reluctant to agree to transfer decision making power to centralised structures, thus illustrating the difficulties encountered in reconciling intergovernmental modes of operation with the inherent supranational character of the Community level.

2.2.3. Progress towards developing coherent European research policies

Member States' strategies and policies for stimulating research and development activity have considerably evolved in recent years towards richer and more complex mixes of measures, tailored to the specific situation of the Member State in question. It is, however, doubtful whether the pace of reform of national policies is commensurate with the challenges at hand.

Though direct links with evolutions at the European level are obviously difficult to establish, an amount of convergence in national policy making is materialising, driven in part by discussion and interaction between Member States and the Community level through e.g. the Open Method of Coordination, through follow-up on Commission Communications or through imitation of priorities established within the Community's Framework Programmes.

There is growing awareness of the fact that research systems do not stop at national borders and transnational cooperation is increasingly being addressed in national policies. Member States have taken a variety of measures supporting their researchers' participation in trans-national actions. However, although actions taken by Member States may be numerous in numbers, the available evidence suggests that the budgets involved in this type of action remain marginal.

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[56] EUROSTARS – in close cooperation with EUREKA – is intended to promote research-intensive SME's by offering funding for their research activities, enabling them to compete internationally and become leaders in their sectors. This network is still being established.

[57] Art. 169 of the EU Treaty enables the EU to participate as an equal partner in R&D programmes conducted by several MS, combining various national and regional programmes into a single joint programme.

[58] Institut Laue-Langevin is an international research centre at the leading edge of neutron science and technology.

[59] The EIROforum is a collaboration between seven European intergovernmental scientific research organisations to pursue joint initiatives, combine resources, and share best practices.

The overwhelming majority of national policy effort (and national budgets) in all Member States is still mainly driven by national considerations and with the ultimate aim to make the national R&D system competitive on the international scale in its own respect. There is only limited evidence of how national policy makers are making considerations of how their policies can contribute to making the European R&D system as a whole more competitive..

Potential tensions between national and Community human resources policies

In addressing the issue of providing an abundant supply of high quality researchers to their R&D systems, Member States have, apart from taking measures aimed at increasing the attractiveness of research careers ('stopping the brain drain'), turned towards measures aimed at attracting scientific talent from abroad towards their respective countries, in some instances focussing in particular on re-attracting expatriate nationals ('reversing the brain drain'), not only from the US, but also from other EU countries (e.g. Cyprus – Expatriate Researchers Programme, Belgium – Odysseus Programme, Austria – Brainpower Austria). In doing so, Member States are effectively trying to consolidate the available scientific talent within their national borders and enter into a competition with other countries, including other Member States, for attracting top researchers.

Community programmes, on the other hand, have always promoted a larger level of fluidity and mobility of researchers throughout Europe, as it would not only enhance the attractiveness of the research profession, but would also contribute to the creation of an open European internal market for knowledge.

This might lead to the conclusion that aspects of the human resources policies of the Member States, justified as they may be from a national perspective, exhibit a certain amount of conflict with the overarching aim of creating a European Research Area where researchers and knowledge can circulate freely.

Considerations of how to deal with the spill over effects that are inherent to R&D policy making, for instance by developing a stronger policy coherence across national borders or between the regional, national and Community levels, are rarely found in Member States' policy documents. Although the coherence of national and Community R&D policies is enshrined in Art 165 of the Treaty, what is clearly not apparent in Member States' policies is reflections of how this coherence should materialise in national policy making, how national policies can go beyond the national perspective and how national policies and Community policy could work together towards establishing a European system of policy making.

It has to be recognised that providing policy makers with the necessary evidence and intelligence concerning public and private sector R&D policies across the EU could help Member States and the Community progress towards the development of more coherent policies. As such, the further development of monitoring systems at the European level (such as ERAWATCH[60]) has a clear contribution to make in this context.

Limited progress in developing scientific and technological specialisations across Europe

Apart from generic support to R&D activities in the public and private sector, most national policy makers nowadays pay attention to concentrating public resources in a limited number of key sectors or technology areas, deemed of strategic importance to their local economies.

The policy tools used to implement this element of specialisation and matching of the research base to the needs of the economy vary widely across Member States, including:

- Thematically structured research programmes (e.g. Austria – FFG thematic programmes, Bulgaria – National Strategy for Scientific Research: thematic priorities, Cyprus – RPF Framework Programme thematic actions, Italy – Strategic programmes, Spain – National Plan for Scientific Research, Development and Technological Innovation – Thematic actions).
- Dedicated public research centres (Belgium – Strategic Research Centres, Netherlands – Leading Technology Institutes, Spain/Portugal joint nanotechnology research centre).

[60] See http://cordis.europa.eu/erawatch

- Public-private partnerships, such as those mentioned above, e.g. competence/ competitiveness poles.

Although these processes of making choices and adding elements of focus and mass to national systems are carried out under varying circumstances and attempting to suit the needs of very different economic structures, they have led to a situation whereby across Europe :

- The range of technologies or sectors being deemed strategic can probably be considered to be too broad for one country to truly build critical mass and develop competitive advantages (e.g. research programmes built around a very broad portfolio of thematic priorities such as in Romania, Portugal or Spain).
- Choices being made display a large degree of similarity across Member States (e.g. ICT (Information Communication Technology), nanotechnology and health are pervasive as priorities across all Member States; priorities such as environmental technologies, energy, materials, agriculture/food, aeronautics and space also being very frequently encountered).
- Building synergies or complementarities across borders or across policy levels is an issue which is rarely addressed, leading to the introduction of clear risks of overlap, duplication and fragmentation.

Therefore, although national R&D policies have addressed the issue of building strategic choices into the system, this has as of yet not led to a situation in which a European system of specialisations has been built in which national policy makers make differentiated choices based on a systematic and synergetic division of labour across Member States and across policy levels.

It is fair to say that Member States have up until now been reluctant to let the ERA project have major implications on the way in which their policies are shaped or their programmes structured and funded, leading to national and Community policies being developed in relative isolation from each other. Member States do not appear to feel a sense of ownership of the ERA project and attribute its ownership largely towards the Community level. As such, the ERA ambition of restructuring the European research fabric, of which national policies are the main components, with a view to addressing fragmentation and avoiding costly duplication of efforts is still far from being achieved.

Some progress towards joint programming of regional and national research efforts

The ERA-NET action was introduced in FP6 as a way for regional and national programmes to engage in dialogues, learn from each other, identify issues where an increased level of cooperation would be beneficial and finally develop joint activities (see section 2.1 for further information on the goals and implementation of ERA-NET: the European Research Area Network). Although it was a measure introduced at the Community level, the attainment of its goals necessitated Member States' participation and commitment.

ERA-NETs aim to establish variable geometry networks pursuing some or all of the elements of a four-step process:

- Systematic exchange of information and good practice on existing programmes and activities.
- Identification and analysis of common strategic issues.
- Planning and development of joint activities between national and regional programmes.
- Implementation of joint trans-national activities, including joint calls and programmes.

There is evidence that ERA-NET has delivered in terms of exchange of information, mutual learning and strategic analysis.[61] Furthermore, by November 2006, 39 ERA-NET coordination actions had progressed towards the fourth step of the process and had implemented, were implementing or were preparing joint calls. ERA-NET participants have up to date committed some € 250 million in the known joint calls, although little of that was spent in open competition, programme owners and managers preferring to keep full control over their own budgets.

There are indications that programme managers and programme owners are reconsidering the design of their programmes with a view to participating in trans-national activities, in particular focussing on aspects relating to management and implementation, including procedural aspects related to e.g. proposal submission and evaluation.

[61] ERA-NET Review 2006, The Report of the Expert Review Group, December 2006.

References to participation in ERA-NET projects are found throughout national policy documents. Though the ERA-NET scheme has obviously provoked large interest amongst national policy makers, there is only limited evidence that Member States have developed a sense of ownership of what the instrument ultimately aimed to contribute to, i.e. a coordinated approach to developing and managing national programmes, which would entail a restructuring of existing programmes to develop synergies, avoid duplication and alleviate existing fragmentation. Rather than as a tool for constructing coordinated research programmes, ERA-NET appears up to now to be mainly seen as a tool for information exchange and cross-border collaboration, in addition to – rather than restructuring or reshaping – existing tools. As such, it has also brought about a certain risk of creating additional fragmentation as it has in effect created an instrument for trans-national collaboration potentially overlapping with the existing ones.

2.2.4. Highlights

- ✓ Although Member States' strategies and policies for stimulating R&D activity have in recent years evolved considerably towards richer and more complex mixes of measures, tailored to the specific situation of the Member State in question, the pace of reform of national policies will need to be accelerated.
- ✓ Some convergence in national policy making is materialising, driven in part by discussion and interaction between Member States and the Community level, such as through the Open Method of Coordination.
- ✓ Trans-national and international cooperation are elements of most Member States' policies, but, with notable exceptions, for the time being are marginal in terms of the overall policy mix.
- ✓ There is limited evidence that Member States have attempted to account for spill over effects, which are inherent to R&D policy making, by building policy coherence both across national borders and between the regional, national and Community policy levels.
- ✓ The overwhelming majority of national policy effort (and national budgets) in all Member States is still mainly driven by national considerations and with the ultimate aim to make the national R&D system competitive on the international scale in its own respect.

Chapter 3: Where are we now?

In this chapter, we analyse some aspects of the current state of the European Research Area: Three issues are covered. Section 1 provides an overview of the new global context for ERA. Three major changes are highlighted: the globalisation of knowledge production, the consensus on global challenges, and the enlargement of the EU. Section 2 describes how since 2000 the roles of some key actors in the European research system have evolved and the challenges they are facing. The focus is in particular on research institutions, private research and human resources. A closer look is also taken at stakeholders' roles and interactions. Section 3 provides an indicator-based look at where Europe is situated today in terms of research and development (R&D) financing and expenditure, and in terms of science and technology (S&T) performance, and ends with some reflections on evidence-based monitoring and evaluation.

3.1 European research: New context and new challenges

What has changed in the context of R&D since the launch of the ERA communication in 2000? What are the consequences for the EU of international actions? This analysis will attempt to provide some responses to these questions.

3.1.1 Some major changes in and outside Europe since January 2000

Three major changes are highlighted: the globalisation of knowledge production, the consensus on global challenges, and the enlargement of the EU. These changes were already present in 2000, but gained in importance since they were added to the political agendas in Europe and beyond. Europe needs to respond proactively to challenges such as climate change, the global economic divide, the currently unsustainable use of natural resources, infectious diseases, global instability and cultural conflicts.

The globalisation of knowledge production

In the 2000 Commission Communication on ERA, Europe compared itself mainly to the US and Japan. Countries like China and India or in South East Asia or Latin America were not mentioned. However, the Communication already pointed to signs of the internationalisation of private R&D, mainly through multinational enterprises (MNEs).

Since 2000, the internationalisation trend has strengthened. Some economists predict that in 2020, the world's largest economies will be the US, China, India and Japan.[62] Other economists predict more modestly that China and India will indeed become major players in the world economy, but certainly not the only ones.[63] The share of world GDP produced by the OECD (Organisation for Economic Cooperation and Development) countries is expected to shrink from about 55% in 2000 to 40% in 2030.[64] Knowledge production and R&D have become part of a global dynamic. As a consequence, an increasing share of global R&D will be located outside Europe. Given the current trends, Europe's share of research will one day represent less

[62] Deutsche Bank Research, "India rising: A medium-term perspective. India Special", International topics Economics, May 2005.

[63] World Bank and Institute of Policy Studies of Singapore, 'Dancing with Giants. China, India and the Global Economy', 2007.

[64] EU Institute for Security Studies, 'The New Global Puzzle. What World for the EU in 2025', 2006.

than 10% of global knowledge production. This raises the question of how to access foreign knowledge, and of how to cooperate to transform knowledge produced elsewhere into innovation in Europe.

The main drivers of the internationalisation of R&D are the growing S&T capacity of China and India and the expanding global knowledge production chains inside MNEs. China and India have emerged as global S&T actors. India increased its R&D spending threefold over the last decade, building on average economic growth of 8% since 2003.[65] China is today one of the world's largest spenders on R&D.[66] Since 2004, China has produced three times more graduates in engineering than the US, and India produces almost the same number of engineers as the US.[67] China has close to the same number of full time researchers as all EU Member States together and India has the largest pool of young university graduates in the world.[68]

At the same time, global foreign direct investment (FDI) flows increased by up to 400% between 1990 and 2004. In 2004, most FDI flowed into Europe, closely followed by South East Asia.[69] This economic evolution affects R&D; MNEs account for half of global R&D expenditures, and are in qualitative terms even more important in the overall innovation process.[70] MNEs enhance global knowledge production chains, mainly through FDI and offshore outsourcing. Offshore outsourcing of business processes has expanded from $1.3 billion in 2002 to $24 billion in 2007. Any given segment of production tends to be outsourced to the most cost-effective location. Firms also profit from offshoring information-centred services (increasingly tradable) to a foreign country, either through FDI or outsourcing.[71]

Global challenges

Since the 2000 ERA Communication, a sizeable degree of global political consensus has been reached on the approach to take to major global challenges, due in no small part, as is widely recognised, to the leadership role played by the EU. Part of this consensus is that S&T has an important part to play.

Since 2000, international political and scientific consensus, including both the US and China, has emerged on the existence of climate change caused by human activity, and on the urgent need for S&T to respond. Convincing scientific evidence was presented in the 2007 report of the Intergovernmental Panel on Climate change.[72] The 2006 Stern Report showed the dramatic consequences of climate change for our quality of life and for economic growth.[73] European citizens are starting to experience the effects of the climate change in their everyday lives.[74] Yet global CO_2 emissions are expected to grow considerably due to the economic expansion of China and India.

Global consensus has also emerged on the so called 'Millennium Development Goals' (MDGs), concrete objectives relating to the eradication of extreme poverty.[75] While global wealth has

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[65] K. Bound, 'India: The Uneven Innovator', Demos, 2007.
[66] J. Wilsdon and J. Keeley, 'China: The Next Science Superpower', Demos, 2007.
[67] Duke University Data, 'Framing the Engineering Outsourcing Debate: Placing the United States on a Level Playing Field with China and India', 2005.
[68] OECD, 'Main Science and Technology Indicators', 2005; K. Bound, 'India: The Uneven Innovator', Demos, 2007.
[69] CNUCED, 'Investment Report', 2006.
[70] UNCTAD, 'World Investment Report', 2005.
[71] EU Institute for Security Studies, 'The New Global Puzzle. What World for the EU in 2025', 2006.
[72] IPCC, 'Climate Change 2007: The Physical Science Basis', WMO/UNEP, 2007.
[73] 'Stern Review: The Economics of Climate Change', 2006.
[74] IPCC,'Climate Change 2007: The Physical Science Basis', WMO/UNEP, 2007.
[75]UN Statistical Division, 'UN MDG Monitoring Indicators', 2005; J. Sachs, 'UN Millennium Project', 2005.

increased, extreme poverty has also expanded in some regions of the world.[76] Countries and large population groups within countries are falling into a poverty trap, lacking domestic S&T capabilities and knowledge to attract FDI and to benefit from existing R&D outcomes by adapting them to their national context.[77] The innovation capacity index is less than 15% in sub-Saharan Africa, as compared to over 50% in emerging economies and close to 90% in Western Europe.[78]

EU enlargement

EU enlargement increases the demand for R&D outcomes. The accession of Romania and Bulgaria has raised the EU population to around 490 million people, the world's third largest population area after China and India. The EU is the world's leading market in terms of purchasing power and demand for knowledge-intensive products, and is likely to remain so in the medium term.[79] Studies have shown that demand for S&T-intensive products is a major driver of R&D location and investment decisions. The problem is, however, that a single EU market for S&T intensive products does not exist yet. Several barriers persist: different national legislation, different technical standards, specificities in local markets, etc.[80]

While the incorporation of 12 new EU Member States since 2000 has further increased the EU's overall R&D capacity, it has also increased the diversity in terms of S&T development gaps, scientific culture and specialisation patterns.[81] The discrepancies between Member States in terms of R&D intensities have also grown larger ranging from 0.4 in Cyprus to 3.86 in Sweden in 2005.[82] The discrepancies between EU regions are now even more marked, with R&D intensity ranging from 0.01 in Severozapaden in Bulgaria to 7.11 in Braunschweig (Germany) (based on reference year 2002, Eurostat data). The share of highly qualified S&T workers in the labour force ranged from over 20% in Denmark, Sweden and Finland to below 10% in Latvia, Austria, Malta, the Czech Republic, Italy, Slovakia and Portugal. Similar variations are seen concerning the number of scientific publications and triadic patent families.

3.1.2 European research in the global context

International S&T co-operation was primarily featured in the Communication 'The International Dimension of the European Research Area'.[83] Many of the issues outlined in that Communication are still relevant today. Global challenges (such as climate change and its consequences, risks of pandemic outbreaks of infectious diseases, etc.) have become even more urgent to the European citizen and the potential role of research in finding solutions and offering new opportunities remains equally important.

The emergence of new research locations and new research emphasis to maintain competitiveness, quality of life and assist developing nations has placed a greater emphasis on international S&T co-operation. What is becoming more urgent is the need at all levels for co-ordination, coherence and visibility, including through leadership, in order to make Europe's

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[76] J. Sachs, 'UN Millennium Project', 2005; EU Institute for Security Studies, 'The New Global Puzzle. What World for the EU in 2025', 2006.
[77] UN Statistical Division, 'UN MDG Monitoring Indicators', 2005; J. Sachs, 'UN Millennium Project', 2005.
[78] UNCTAD, 'World Investment Report', 2005.
[79] EU Institute for Security Studies, 'The New Global Puzzle. What World for the EU in 2025', 2006.
[80] Independent High Level Expert Group on R&D and Innovation, chaired by Esko Aho, 'Creating an Innovative Europe', January 2006.
[81] DG Research, 'Key Figures 2005'.
[82] NEWCRONOS, OECD, DG Research.
[83] COM(2001)346, 'The International Dimension of the European Research Area'.

international S&T more effective, maintain the attractiveness of Europe as a place to do research and to do research with.

The vision for 2020 developed in the ERA Green Paper has been put forward on the basis of an analysis of the dynamic situation, supported by the findings of a number of reports and working groups. However, it is also clear that a more systematic approach to evaluating the evolving picture, including assessment of impacts, will be increasingly required in the future to successfully maintain and adapt the European S&T response to world developments.[84]

Prioritising international co-operation

The 7th Framework Programme (FP7) ensures that budgets for international cooperation are built in at the level of each of the relevant calls for proposals. These actions are aimed at reinforcing research capacity in non-associated candidate and neighbourhood countries and at addressing the particular needs of developing and emerging economies.[85] However, at present no system exists at the European level to identify horizontal priorities for international S&T co-operation with third countries across all subject areas. The development of a transparent approach for prioritising S&T co-operation with third Countries might provide the basis for developing co-ordination of European actions and a 'common voice' for ERA.

'Speaking with one voice': Co-ordination of Member States policies on international co-operation with EU policies

A new consensus is emerging across Europe with the recognition that Member States face similar challenges and opportunities arising from globalisation. Specifically for research these include: increasing excellence; enhancing international attractiveness; responding to international commitments; and maintaining or increasing global competitiveness through innovation are common aspirations. Several Member States have taken steps to develop internationalisation research strategies in response to these challenges and, through the CREST mechanism[86], Members States are seeking to learn from one another and develop a deeper common understanding. This provides the necessary preliminary step towards consideration of common action at the European level.

Addressing the fragmentation of European research through co-operation will open ways of accessing knowledge and market opportunities abroad, and entails an immense potential in producing new knowledge and ideas, simply through joining forces.[87]

Closer linkage between research and Europe's external relations

[84] The recently launched ERAWATCH, EU Industrial Research Investment Monitoring (IRIM), and Integrated Information System on European Researchers (IISER) platforms will provide relevant background evidence.
[85] € 22582, 'A New Approach to International S&T Cooperation in the EU's 7th Framework Programme (2007 – 2013)'.
[86] The Scientific and Technical Research Committee (CREST) advises the Research Council and the European Commission on issues of European RTD policy.
[87] CREST Internationalisation WG mandate.

Increasingly the EU's internal policies have been shown to impact on international relationships which requires greater vigilance to ensure coherence between research and other policies is maintained and enhanced.[88] This is particularly true of research which, although the bulk of the activities are directed towards Member States, has always formed an important facet of Europe's relationships with third Countries. The 2005 impact assessment of EU international research co-operation noted that societal impact would be more profound, widespread and sustainable, if relevant Community policies became more effectively convergent and integration and prioritisation of various national public policies had taken place in partner countries.

Improving instruments of co-operation

S&T agreements have played an important part as an instrument of the formal co-operative arrangements between the EU and a selected number of third countries. However, despite the benefits to the strengthening of relationships, the existence of such agreements has, in many cases, had limited direct impact on third country participation in the Framework Programme or the reciprocal opening of third country research programmes to EU scientists. Furthermore, links to naturally synergistic policy areas of foreign relations, development, trade and environment and their intervention modes have been weak.[89]

S&T agreements need to be supported by appropriate conditions for effective encouragement of co-operation. In this context, protection of intellectual property rights (IPR) (which is not unanimously agreed upon or implemented in all countries) remains a potential barrier to research co-operation with some third countries.

Closer links to neighbouring countries

The EU has a declared vital interest in seeing greater economic development and stability and better governance in its neighbourhood and it is therefore in their best mutual interest to build a much stronger and deeper relationship.[90] Research can play a part in supporting this process, helping to achieve a level of integration and joint ownership in the field of research where a number of countries might be appropriate for consideration of full association to future framework programmes.

The means for achieving greater integration by the ENP countries in the EU's framework programmes for research will be via the research priorities developed in the individual work programmes.

Developing joint responses to global challenges

[88] COM(2006) 278 final, 'Europe in the World — Some Practical Proposals for Greater Coherence, Effectiveness and Visibility'.
[89] INCO FP7 Impact Assessment.
[90] COM(2006)726, 'Strengthening The European Neighbourhood Policy'.

Europe's researchers have the responsibility to show scientific leadership in addressing global challenges. Co-ordination and coherence of purpose demonstrate this leadership and further enhance the attractiveness of Europe as a research partner. Moreover, Europe is the most important aid donor giving leverage in terms of social justice and human rights around the world. In other related fields such leadership has demonstrated significant benefits for Europe. For example, the EU's influence on international environmental standards has contributed to creating a level playing field for EU's businesses and fostered the export potential of our clean technologies.[91]

3.1.3 Highlights

- ✓ What has changed in the context of R&D since the launch of the ERA communication in 2000? Three major changes are highlighted: the globalisation of knowledge production, the consensus on global challenges, and the enlargement of the EU. These changes were already present in 2000, but gained in importance since they were added to the political agendas in Europe and beyond.
- ✓ Global challenges (such as climate change and its consequences, risks of pandemic outbreaks of infectious diseases, etc.) have become even more urgent to the European citizen and the potential role of research in finding solutions and offering new opportunities remains equally important.
- ✓ The emergence of new research locations and new research emphasis to maintain competitiveness, quality of life and assist developing nations has placed a greater emphasis on international S&T co-operation. What is becoming more urgent is the need at all levels for co-ordination, coherence and visibility, including through leadership, in order to make Europe's international S&T more effective, maintain the attractiveness of Europe as a place to do research and to do research with.

3.2 European Research: Shifting roles of actors and stakeholders

3.2.1 Research institutions

R&D in Europe involves three main types of institutional actor: enterprises, universities,[92] and public research organisations. They complement one another and all contribute importantly to ERA. Public research organisations are entities *"which as their predominant activity provide research and development, technology and innovation services to enterprises, governments and other clients…"*. This definition distinguishes public research organisations from universities, which have education at the core of their activities, and from enterprises, which primarily produce goods and services for commercial purposes. The situation of research undertaken by enterprises is covered in section 3.2.2.

3.2.1.1 Universities

[91] COM(2006) 278 final, 'Europe in the World — Some Practical Proposals for Greater Coherence, Effectiveness and Visibility'.

[92] The term "universities" here covers higher education institutions, irrespective of their name and status in national law.

Current situation

Universities are key actors in both the European Higher Education Area (EHEA) and the European Research Area (ERA). Their importance in relation to ERA is illustrated by their share in total research expenditure, which is around 22% in Europe, compared to some 14% in the US and Japan (Table 3.1). Research active universities are the main producers of scientific knowledge in Europe today, acting as 'knowledge creators' and an important training ground for researchers. In Europe, universities employ about 36.6% of researchers (2004), compared to around 14.7% in the US (2000) and 25.5% in Japan (2003) (Table 3.1).[93] Research-active universities also contribute to economic competitive advantages through consultancy, access to specialist know-how and facilities, and other forms of knowledge transfer.

This prominent role of research-active universities in the production and dissemination of knowledge is well documented and has led many public authorities to 'preserve' their universities at national or regional level, by subjecting them too often to detailed regulations and fostering a large degree of uniformity among them. [94] For the most part this has resulted in the continued fragmentation of the sector into mostly small scale national systems and sub-systems, with few incentives for competition or collaboration at national level, let alone competition at European or international level.[95]

Although there is a general lack of precise and comparable data on research-active universities in Europe**,** there is evidence of public authorities and universities working to address fragmentation. However, this tends to be aimed at building 'national champions', rather than developing the ERA. These initiatives range from actions of public administrations to concentrate research resources available to national universities, to measures undertaken by individual universities from different countries to deepen their links. There are also important efforts by different university groupings, both smaller [e.g. the League of European Research Universities (LERU)] and larger [e.g. the European University Association (EUA)], to foster trans-national alignment of different institutions based on policy discussion and exchange of good practices. Indeed, the commitment of a significant number of universities to trans-national research can be seen from the fact that 33% (or 6400) of the FP6 participations (contract signed in 2005) were higher education institutions.[96]

Nonetheless, and again taking into account that systematic, comparable data are not available, the overall situation in Europe in terms of quality of university-based research can be at best characterised as generally good on average, but with a very limited basis of universities at world-level, indicated by several international universities rankings,[97] as well as publication patterns of scientific articles.[98]

Trends and problems experienced

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[93] Most recently available data: EUROSTAT (The European Commission's Statistics Office).NewCronos dataset January 2007 extraction.

[94] COM(2003) 58, 'The role of universities in the Europe of knowledge' and the report by the Forum on university-based research; 'European Universities: Enhancing Europe's research base', 2005. See also the 2003 report 'Measures to improve Higher Education/Research Relations in order to strengthen the strategic basis of the ERA' by the 'STRATA-ETAN expert group on foresight for the development of higher education/research relations'.

[95] COM(2006) 208, 'Delivering on the modernisation agenda for universities: education, research and innovation'.

[96] 'FP6 Contracts signed in 2005: Participation and Contribution by Priority Area and Type of Beneficiary', (Table 3b, page 10 of the statistical Annex) of COM (2006) 685, 'Annual Report on research and technological development activities of the European Union in 2005'.

[97] See for instance the Shanghai Ranking of World Universities 2006 where only 34 out of the top 100 universities are located in Europe, compared to 207 out of the top 500.

[98] See section 3.3.2. " Citation impact score of world's largest research universities".

It would therefore appear that not enough public authorities and universities in Member States seem to respond to the challenges arising from the globalisation of the knowledge economy, and thus to their own role in a European Research Area, which offers a frame for that response.

In their contribution as part of ERA to the development of Europe, universities engaged in research are increasingly required, with the support from the public administration, to take a strategic position on a number of key issues, including their research portfolio, research quality and their opening beyond academia. A number of bottlenecks have been identified.[99]

Concentration and diversification

The current situation in the EU, in which the average quality of university research is good but not enough excellent, can be traced in part to difficulties with the strategic positioning of universities in terms of their strengths in research and the particularities of their environment. A systematically pursued positioning would have consequences for the choice of research portfolios of each institution, with expected concentration and diversification of research means and efforts.

University-based research in the EU would appear to be much less concentrated on average than in the US if one compares the research budget size of the top universities, as well as the total share of the national research budget channelled to these top institutions in both continents.[100]

Tackling these issues of research spending and research portfolios would require the emergence of a diverse system of university-based research with not only institutions that are global players, but also those that are 'national champions' and those that feed the economic and societal development at regional and sectoral level. A prerequisite for taking this stratification beyond national level is that the ERA-dimension of university research is fully recognised.

Autonomy and accountability

In order to seize opportunities linked to a dynamic environment concerning research port-folios and agendas, universities may need to become more autonomous. However, there are difficulties both in the insufficient granting of such autonomy, and in the ability to take it up. Linked to the latter is the capacity of universities to further professionalize the way research is conducted and managed, and to position themselves in a new competitive context by making and following through on the necessary strategic and managerial choices.[101] This in turn, hinges on factors such as a professional and autonomous recruitment policy.

Greater autonomy goes hand in hand with increased internal and external accountability. External accountability can be enhanced through mechanisms such as increased communication on university activities, demonstrating to sponsors the effective use of budgetary resources, and developing assessment tools to evaluate their institutional performance. Internal accountability could be reinforced by strengthened leadership, more transparent recruitment procedures, explicit staff promotion mechanisms and implementing models of research staff remuneration that incorporate co-funding of basic salary with other sources.[102]

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[99] See for instance COM(2006) 208, 'Delivering on the modernisation agenda for universities: education, research and innovation'.

[100] Data suggest that the top 5 publishing EU universities are spending on average half the budget of the top 5 US research universities; equally so, compared to the top 5 publishing EU universities, the top 5 publishing universities in the US spend double the share of the total research budget channelled through universities.

[101] OECD, 'University Research Management: Meeting the Institutional Challenge', Paris, OECD, 2004.

[102] This could, for example, be achieved by allowing researchers to complement their basic salaries through bonuses linked to the securing of external competitive funding, to participate in royalty benefits schemes from

Although in some countries such as the United Kingdom, Ireland, Finland, Sweden, the Netherlands, and recently also Denmark and Austria, wide-reaching autonomy is granted to universities, with clear requirements for accountability, progress in many Member States is slow.[103]

Output driven funding mechanisms

It is generally accepted that responsiveness and research quality benefit greatly from funding mechanisms that provide universities with clear incentives to that end, based more than now on output and competition. However, many universities still receive public funding for research based exclusively on traditional indicators of inputs or non-research related parameters (number of students, number of researchers, applications for research funding, success rates in applications, number of diplomas), rather than on an institutional evaluation which also relates universities' input to their economic and societal outputs. Across Europe there also appears to be a wide variety in the share of so-called base funding versus and public project-based funding, the latter of which is normally based on competition either within a university, country or at European level.

Opening beyond Academia

The essential mission of academia is producing new knowledge answering societal needs (including needs of business and industry) and disseminating this new knowledge to all stakeholders or users.

By sharing knowledge with society, universities better communicate the relevance of their research activities. Not only do such interactions enable them to focus their research agenda on topics relevant for society, and better address citizens' concerns, but they also help universities to win the support of policy makers and society at large.[104] Universities should therefore have strategies to enhance dialogue with citizens and to facilitate access of SMEs and non-commercial entities to the results of their research.[105]

Identifying and answering societal needs means first using 'problem solving' methodologies in the training of young researchers and in the implementation of research projects. This way of addressing concrete problems also implies more open and trans-disciplinary approaches. However, one of the most important barriers at the moment to a more dynamic research process is the strongly disciplinary organisation of the university system.

Another key challenge for Europe is to become better at stimulating the use of knowledge -the fruit of research- by industry and society in general. Active support for the wide dissemination of research and for the application of research results to the benefit of society is a key element for the success of research-active universities.[106] From a societal perspective, more will be gained by letting our universities excel in knowledge creation while encouraging closer links with the rest of society, than by insisting that they should fund themselves mainly through commercializing their knowledge.[107] The development of strong and sustained structured partnerships between universities and the surrounding society, including regional authorities,

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intellectual property rights exploitation resulting from their research work. See Link, A. N. and Siegel, D. S. (Eds), 2005, 'Special Issue: University-based Technology Initiatives', Research Policy, 34.

[103] EUA, 2005, 'Trends IV: European Universities implementing Bologna'.

[104] Weber and Duderstadt, 2004, 'Reinventing the Research University', Economica, London.

[105] 'European Universities: Enhancing Europe's Research Base', 2005, report by the Forum on University-based Research.

[106] Taylor, 2006, 'Managing the Unmanageable: The Management of Research in Research-intensive Universities', Higher Education Management and Policy, 18 (2), pp 9-34, OECD.

[107] 'European Universities: Enhancing Europe's Research Base', 2005, report by the Forum on University-based Research.

businesses and SMEs, has a direct impact on improving the economic performance of the whole region, through localized technological spill-overs, while at the same time being beneficial to universities.[108] Such partnerships also provide leverage for universities to obtain additional funding through expanding their research capabilities; as well as securing alternative career prospects for their researchers through inter-institutional placements, exchanges of staff and intersectoral mobility, thus generating positive effects on the research performance of academic researchers.[109]

These partnerships include patenting, licensing, research collaborations with industry or the creation of innovative spin-offs. Without this market-driven interaction with R&D intensive companies, the impact of publicly funded university-based research on regional, national and European economies will inevitably be limited. An important transfer of knowledge and experience between universities and industry is achieved through inter-institutional exchange of people. Indeed, 'the best forms of knowledge transfer involve human interaction', and European society would greatly benefit from the cross-fertilisation between university and industry that flows from promoting intersectorial mobility.[110]

Table 3.1 Key data on the higher education sector

	% of GERD performed by HES 2000-2005 (a)		**Researchers in HES as % of national totals (FTE) 2000-2005 (b)**		**Researchers in HES (FTE) 2000-2005 (c)**	
	2000 (1)	**2005 (2)**	**2000 (3)**	**2005 (4)**	**2000 (5)**	**2005 (6)**
European Union -25	20.9	22.2	37.0	36.6	398,548	445,780
Belgium (BE)	20.3	22.5	38.6	41.2	11,778	13,168
Bulgaria (BG)	9.6	10.0	19.9	25.9	1,886	2,607
Czech Republic (CZ)	14.0	16.2	27.2	31.3	3,768	7,576
Denmark (DK)	19.6	23.8	30.2	29.4	5,813	8,287
Germany (DE)	16.3	16.7	26.0	24.6	67,087	66,000
Estonia (EE)	52.5	41.5	67.7	57.2	1,806	1,905
Ireland(IE)	22.0	28.0	25.2	38.0	2,148	4,240
Greece(GR)	49.3	49.2	71.0	60.2	10,471	10,251
Spain (ES)	29.7	28.6	54.9	49.0	42,064	53,779
France FR)	18.6	19.7	35.8	32.7	61,583	65,498
Italy (IT)	30.5	32.7	38.9	39.2	25,696	28,226
Cyprus (CY)	25.0	37.5	42.2	59.5	128	375
Latvia (LV)	38.6	40.4	56.5	67.8	2,156	2,224
Lithuania (LT)	37.3	55.3	63.4	67.0	4,932	5,116
Grand Duchy of Luxembourg (LU)	0.0	1.3	1.3	8.4	22	176
Hungary (HU)	24.4	25.5	40.6	37.2	5,852	5,911
Malta (MT)	61.5	27.9	74.6	50.9	203	225

108 See, for instance: 'The Lambert Review of Business-University Collaboration', HM Treasury, December 2003.
109 See Van Looy, B. et al., 2004,'Combining entrepreneurial and scientific performance in academia: towards a compounded and reciprocal Matthew-effect?', Research Policy, 33(3), pp. 425-441.
110 Lambert Review of Business-University Collaboration, reference above.

Netherlands (NL)	28.0	28.1	36.8	27.4	15,480	10,211
Austria (AT)	26.9	26.7	28.9	31.9	6,977	8,999
Poland (PL)	31.3	31.6	62.1	65.1	34,246	40,449
Portugal (PT)	36.8	39.5	51.3	53.0	8,592	11,138
Romania (RO)	10.8	10.3	12.4	26.6	2,542	5,654
Slovenia (SI)	16.8	9.8	30.9	19.4	1,340	742
Slovakia (SK)	9.2	19.6	50.3	59.1	5,009	6,458
Finland (FI)	18.0	19.0	..	32.5	10,405	12,879
Sweden (SE)	21.3	20.7	36.6	31.1	14,623	16,792
United Kingdom (GB)	20.4	23.1	22.7	..	29,000	..
United States (US)	11.4	13.5	14.7	..	186,027	..
China (excl. Hong Kong) (CN)	8.9	10.6	21.3	21.6	147,866	185,987
Japan (JN)	14.4	13.8	27.7	25.5	179,116	172,396

Source: (a) EUROSTAT, NewCronos Dataset, January 2007 extraction; (b) EUROSTAT, NewCronos Dataset, January 2007 extraction; (c)

Notes: (1) 1999: GR, SE; 2002: AT, MT (2) 2004: IT, RO, NL, UK, US 2003: CN, JP (3) 1998: UK; 1999: DK, GR, SE, US; 2002: AT, MT (4) 2004: EU-25, FR, IT, RO; 2003: NL, CN, JP (5) 1998: UK; 1999: GR, SE, US; 2002: MT, AT (6) 2004: EU-25, FR, IT, RO; 2003: NL, CN, JP.

*3.2.1.2 **Public Research Centres and other RTOs** (Research and Technology Organisations)*

Research and Technology Organisations are organisations "which as their predominant activity provide research and development, technology and innovation services to enterprises, governments and other clients…"

This broad definition encompasses several categories of organisations, including in particular public research centres but also private ones, while noting that there exists a full spectrum of situations in-between.

Often created directly by government – or by publicly sanctioned collectivities (e.g. industrial branch organisations) – public research centres originally had, at the time of their creation, a clearly public profile: a publicly ordained (collective) mission paid for with public (collective) funds.

Today, the profile of many of these public research centres and organisations has changed. Many fulfil one or more public mandates, and receive corresponding public funding, but at the same time also provide services commercially to enterprises. Indeed, some are required to sell services commercially as part of their public mandate.

Indeed, most RTOs have a **mixed funding structure** in which governmental funding (both grants and ´competitive funding´) is combined with contract work in which a client directly pays for a specified service or product. It is also common for RTOs to gain additional income from licensing intellectual property (patents, copyright etc) or from spin-offs and start-ups.

Table 3.2: Funding structure of a number of RTOs.

	Core funding/grant (% of total funding)	**Contract research (% of total funding)**

CSIRO	66	34
Fraunhofer	40	60
Joanneum research	25	75
SINTEF	7	93
TNO	34	66
VTT	30	70
IMEC	24	76
DPI	50	50

Source: TNO 2005, limited comparability because of differences in calculated costs and labelling of funding categories.

The distribution of funding[111] presented above is typical for RTOs with a strong applied technology orientation. Even public research centres which started as fully publicly funded fundamental research organisations are now broadening their funding base by engaging in strategic research programs (such as the EU framework programme) and contract research. In the case of the Max Planck Society these additional funding sources represent about 20% of the budget, even though none of this is formally labelled as contract research.

In addition, even if most of their activities are linked to scientific research, some RTOs have activities which are quite far removed from the field of technology, like labour market studies in TNO, Fraunhofer and Joanneum Research, health care systems performance research in TNO, or management support in SINTEF and VTT.

Thus RTOs do not represent a homogeneous category since many are mixed-economy institutions[112] and cannot be classified as "public".

Moreover, the borders between RTOs and universities are increasingly blurred by several factors: not only do certain universities actively engage in industrial collaborations and in the commercialisation of their R&D results, but in addition several RTOs have developed educational activities. This means that most of the above considerations regarding universities (more specifically university research) also largely apply to RTOs.

Furthermore, the overall reduction in direct government funding, changing ownership (more shareholders) or legal positions (at ´arms length´), has led to a growing managerial independence of RTOs. Most RTOs are now responsible for their own strategic development, within usually fairly broad boundaries set by their owner, main shareholder or legal mission. This has generally led to a growth of entrepreneurial behaviour in RTOs, such as: expansion outside of the home country, take over of smaller RTOs and increased professionalisation in the field of knowledge transfer (IP-management, spin-out creation, etc).

To take an example of this multi-faceted approach, the French CEA (*Commissariat à l'Energie Atomique*[113]), includes a dedicated training institute (INSTN). The INSTN hosts about 7000 trainees every year in vocational sessions and 600 students take academic courses, in addition to the thousand doctoral researchers which are employed directly by the CEA. Furthermore, they have about 350 licensing agreements in force, and have set up 93 new high-technology companies since 1984

Similarly, the *Fraunhofer-Gesellschaft*[114] is made up of 56 institutes staffed by a total of roughly 12 500 employees, engaged in research in hundreds of areas of technology, the results of which are made available to industry in the form of patents, licenses, training courses and

[111] The future of RTOs: a few likely scenarios, Jos Leijten, Contribution to the DG Research expert group on the future of key actors in the European Research Area
[112] http://ec.europa.eu/research/eurab/pdf/eurab_05_037_wg4fr_dec2005_en.pdf
[113] http://www.cea.fr/le_cea/presentation_generale
[114] http://www.fraunhofer.de/fhg/EN/

above all through contract research projects. The *Fraunhofer Gesellschaft*'s activities include both pure basic research, as practiced at universities (funded to almost 100% by public grants) and industrial R&D, up to prototype level (largely financed by the private sector). Its licensing revenues exceed 50 M€ per year.

The Dutch *TNO*[115] applied research centre was established in order to support companies that did not have internal R&D capacities. With 4648 employees and a consolidated turnover of 562 M€ in 2005, TNO is a public but independent organisation that offers objective scientific assessments. In most cases TNO's customers exploit themselves the knowledge developed by TNO, but it also is commercially active by putting the knowledge it develops directly into the marketplace. This commercialisation is in the hands of *TNO Companies BV*[116], a distinct legal entity.

A detailed study on RTOs is given in a comparative analysis of European research centres compiled by PREST on behalf of the "Eurolabs" project consortium. The data come from a data base with 769 European R&D organisations. The following summarised data provide a snapshot of RTOs in the EU-15:

- Most RTOs are active in applied research (92%) and development (80%), about half of them in diffusion/extension (67%) and basic research (52%), and some in certification/standards (32%) and in the provision of facilities (33%).
- Predominantly, their skills base is in engineering and technology (63%) and natural sciences (58%), and to a lesser extent in agriculture, medicine and social sciences (27%-32%) and humanities (languages, culture, societal issues) (10%).
- RTO's predominant linkages are with national authorities (89%), industry (77%), the European Community (74%, mainly through the EC Framework Programmes) and universities (74%), and to a lesser extent with regional authorities (53%).

Despite the fact that most RTOs have experienced many changes since their establishment, many of their fundamental missions have not changed[117]. That said, the growing effect of internationalization can be seen in core RTOs activities. For example, the German Max-Planck-Gesellschaft also has research centres in Italy and the Netherlands. In addition, its "International Max Planck Research Schools" focus particularly on international cooperation and strive to attract foreign students to Germany to pursue their Ph.D. studies.

In recent years, although RTOs are largely still national organisations, subject to national policies and governed by national bodies, there has been a drive to strengthen their sustainability and to leverage additional funding from international sources.

In this context, the Framework Programme has had a significant incentive effect towards promoting competition between RTOs for funds and for SME clients across Europe. Indeed, the scheme "*Supporting SMEs outsourcing research activities*" which is dedicated to SMEs and SME associations in need of outsourcing research to providers of research services ('RTD performers') has been at the heart of this change in RTO's behaviour. The scheme, whose budget currently stands at 1300M€ for the 2007-2013 period, has incentivized several major European research institutions to adapt their strategies in order to promote the development of transnational links (with other research providers and with SMEs) rather than focus on a purely National market.

[115] Toegepast Natuurwetenschappelijk Onderzoek (Applied Science Research) – http://www.tno.nl/index.cfm?Taal=2

[116] http://www.tno-bedrijven.nl/tno/locale/select.do?scope=ui&localeid=en_GB

[117] The future of RTOs: a few likely scenarios, Jos Leijten, Contribution to the DG Research expert group on the future of key actors in the European Research Area

Furthermore, some European RTOs are seeking more permanent ties with their like to maximize market links and facilitate cooperation in different Member States. For example, TNO took a 10% share in Joanneum Research in 2004 (the other 90% belongs to the government).

Certain RTOs are even developing broader market strategies, in order to serve their growing international client base, several RTOs have established foreign offices (e.g. SINTEF in Houston, the heart of the US oil industry and TNO in Detroit, heart of the US car industry). Only in the case of the fully privatised RTOs, such as the former UK defence research labs now called Qinetiq, has internationalisation been taken a step further. Qinetiq is partly owned by a US based investment company and the British government considers a further sale of shares.

It is thus clear that RTOs play a key role in the European research landscape, as they exert an impact not only regarding R&D per se but also in the education and innovation areas, and are therefore contributing significantly to enhance Europe's competitiveness.

3.2.2 Private research

While most fundamental research is conducted in public institutions, the majority of all research and development is conducted in the private sector, and concentrated in a very limited number of large companies. In Europe, industry carries out close to two thirds of all R&D activities. According to official R&D statistics for the EU-27, expenditure on R&D is distributed as follows: business (BERD) represented €128 billion in 2005 (64% of total), universities and higher education research and development spending (HERD) €44 billion (22%) and governmental research organisations spending (GOVERD) €26 billion (14%).[118] If we consider the EU top 1000 R&D investors at enterprise group level, the top third accounts for about 95% of the total R&D spent.[119] Moreover, Europe has more than its share of the world's top 50 R&D investors: 20 are European companies, from which six rank amongst the ten fastest R&D growers.[120] Large European companies' performance levels of R&D investment are comparable to those of their counterparts outside the EU. The total BERD in Europe - which is not only determined by the large enterprise groups – remains, however, relatively low in comparison to that of the US or Japan.

These few figures clearly demonstrate the key importance of industrial private research in Europe. To further investigate this issue, the following sub-sections provide:

- ✓ More detailed analyses of different aspects of private R&D (*3.2.2.1 – Measuring private research*), including the influence of company size.
- ✓ An overview of the framework conditions which affect private investment in R&D (*3.2.2.2 – Leveraging private research*), including Internal Market rules, the State aid framework for R&D, intellectual property (IPR) issues, etc.

Moreover, the sub-section 3.2.4 – *Stakeholders' roles and interactions* is complementary to this one, as it includes in particular a number of considerations on relations between industry and research institutions.

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[118] BERD refers to all R&D activities performed by businesses within a particular sector and territory, regardless of the location of the business' headquarters, and regardless of the sources of finance. It therefore focuses on R&D activity within the countries, independent of the source of funding and, at the national level, exclude R&D carried out by companies in other countries; OECD, 'Main Science and Technology Indicators', 2006.
[119] European Commission – DGJRC-IPTS and DGRTD - *The EU 2006 Industrial R&D Investment Scoreboard* . http://iri.jrc.es/research/scoreboard_2006_data.htm
[120] EU + Switzerland.

3.2.2.1 Measuring private research

This sub-section analyses some of the implications of industrial research investment for EU policymaking. The analysis is based on the one hand on official R&D statistics. On the other hand also the data from the 2005 and 2006 'EU Industrial R&D Investment Scoreboards' are used. The former data source provides the R&D expenditure performed by all R&D performers in a country. The latter provides detailed information on the top 1000 EU and top 1000 non-EU companies investing the most in R&D, taken from the annual financial reports published by these companies. Due to different concepts and definitions both data sources are not comparable, but rather complementary.

EU R&D expenditure by size classes

Table 3.3: Business R&D expenditure by size class, in million euro and as a % of total, EU and selected countries, 2003

	TOTAL € million	Small enterprises € million	Small enterprises as a %	Medium enterprises € million	Medium enterprises as a %	Large enterprises € million	Large enterprises as a %
EU25	**120.991 s**	**:**	**:**	**:**	**:**	**:**	**:**
EU15	**119.461 s**	**:**	**:**	**:**	**:**	**:**	**:**
BE	3.608	577	16,0	1.174	32,5	1.857	51,5
BG	18	3	16,7	5	29,7	10	53,6
CZ	618	59	9,5	217	35,2	342	55,4
DK	3.355	504	15,0	931	27,7	1.919	57,2
DE	38.029	738	1,9	4.153	10,9	33.139	87,1
EE	23	5 i	23,8	10	45,7	7	30,4
IE	1.076	244	22,7	441	41,0	390	36,3
GR	313	60	19,1	129	41,0	125	39,9
ES	4.443	814	18,3	1.731	39,0	1.899	42,7
FR	21.646	:	:	:	:	:	:
IT	6.979	:	:	:	:	:	:
CY	9	3	32,4	2	24,4	4	43,2
LV	13	6	47,2	4	27,1	3	25,8
LT	23	2	10,6	15	63,7	6	25,7
LU	379	:	:	:	:	:	:
HU	255	30	11,9	55	21,6	169	66,5
MT	3	1	41,7	1	50,0	0	8,3
NL	4.804	:	:	:	:	:	:
AT	3.556	340	9,6	994	28,0	2.222	62,5
PL	284	19	6,7	157	55,4	108	37,9
PT	338	66	19,6	138	40,9	134	39,5
RO	118	18	15,0	47	39,4	54	45,5
SI	209	:	:	:	:	:	:
SK	93	14	14,9	51	55,1	28	30,0
FI	3.528	309	8,8	734	20,8	2.485	70,4
SE	7.886 i	0	0,0	1.420	18,0	6.466	82,0
UK	18.319	1.149	6,3	4.662	25,4	13.967	76,2
IS	142	:	:	:	:	:	:
NO	1.960	:	:	:	:	:	:
EEA28	**123.093 s**	**:**	**:**	**:**	**:**	**:**	**:**
CH	6.257	503	8,0	1.485	23,7	4.269	68,2
RU	3.176	1.288	40,5	1.738	54,7	150	4,7

Exceptions to the reference year:
2002: MT and RU
2004: AT and CH

small enterprises: 0 to 49 employees
medium enterprises: 50 to 499 employees
large enterprises: more than 500 employees

In most European countries the R&D expenditure concentrates in enterprises with more than 500 employees. More than half of the national R&D expenditure was performed in these enterprises in most Member States. For Germany – the largest R&D performer in the EU - even 87 % of the national R&D was done in large enterprises. However, in a number of new Member States - such as Poland, the Slovak Republic and Latvia - small and medium sized enterprises also performed a considerable share of the national R&D.

R&D ratios (R&D investment as a % of sales) at company level

R&D affects the growth and performance of an economy through its output and use of innovation. The commercial exploitation of research involves improving existing products, introducing new products and services where they meet demand, and redesigning production methods. Such product or process orientated innovations affect whole sectors and have spill-overs to other parts of the economy. However the link between the R&D input of an economy and its innovation performance is not always straightforward. When comparing R&D investment of the top investors worldwide, it is useful to analyse how it is distributed among different groups of companies defined in terms of their R&D ratio (R&D investment as % of sales): High R&D ratios (Group 1), Medium R&D intensity (Group 2), Low R&D intensity (Group 3) and Very low R&D intensity (Group 4).

A contrasting picture is offered by EU companies: whereas the average R&D intensity in the EU (2.9%) is much lower, in particular *vis-à-vis* US companies (4.4%), expressing it by R&D intensity groups (high, medium, low, very low) EU companies have higher R&D intensities than the US's for all of the four groups. This paradox is only apparent and due to the sector composition of EU industry - only 35% of EU-based companies belonged to group 1 (High tech), compared to 67% in the US. The majority of EU-based companies were in Group 2 (Medium tech), reflecting a more traditional economic specialisation.

The top EU R&D investors tend to perform at least as well in terms of R&D investment as their counterparts outside the EU. For example, there is the same number of EU and US companies among the top 50 R&D investors in the world. There are 20 European[121] companies, 18 from the US and 10 Japanese companies. Furthermore, there are few sectors where there is not at least one EU company in a leading position – even in highly R&D intensive sectors such as IT hardware and electronics & electrical equipment.

In contrast with that achievement, there are too few EU based companies with high R&D intensities which are comparable in size and sales volume to the top investors in the world. Europe suffers from a scarcity of medium-to-large companies in which R&D drives growth. There may also be a problem of successful innovative enterprises that stay relatively small.

Table 3.4: High-tech sectors in the EU Member States — 2003

[121] EU + Switzerland

	High-tech manufacturing				Total high-tech sectors (1)	High-tech knowledge-intensive services			
	Number of enterprises	Turnover in EUR million	Prod. value in EUR million	Value added in EUR million	Labour productivity in EUR thousands	Number of enterprises	Turnover in EUR million	Prod. value in EUR million	Value added in EUR million
EU-25	**134 895 s**	**:**	**:**	**:**	**69 s**	**528 935 s**	**770 994 s**	**715 568 s**	**385 874 s**
EU-15	**103 259 s**	**:**	**:**	**:**	**73 s**	**470 564 s**	**749 769 s**	**697 871 s**	**375 923 s**
BE	1 887	15 020	15 554	6 279	91	13 982	22 814	22 440	11 167
CZ	8 288	: c	6 817	1 296	22	25 035	6 917	6 342	3 489
DK	1 085	9 261	9 240	4 007	78	7 802	14 285	14 170	6 931
DE	19 987	143 358	125 240	46 918	71	53 335	148 362	129 666	79 130
EE	250	: c	: c	: c	28	872	683	656	325
EL	:	:	:	:	:	:	:	:	:
ES	7 826	22 850	21 227	6 538	66	32 680	51 341	41 458	25 695
FR	16 635	147 185	135 542	35 757	71	52 920	114 626	111 805	57 194
IE	309	30 458	30 036	8 714	142	4 971	16 326	11 607	7 408
IT	33 447	59 482	57 327	18 896	65	96 738	93 386	92 220	44 801
CY	85	90	89	37	75	231	538	525	429
LV	212	: c	: c	: c	22	1 097	763	711	456
LT	363	379	384	125	16	1 348	972	897	403
LU	63	: c	: c	: c	115	1 095	2 210	1 964	1 211
HU	5 685	13 887	12 940	2 715	27	24 932	7 374	5 027	2 896
MT	:	:	:	:	49	684	314	312	230
NL	3 055	: c	: c	: c	79	22 890	40 094	38 658	20 912
AT	1 751	10 816	9 629	3 961	72	13 667	14 965	11 069	7 354
PL	15 398	7 789	7 095	2 498	19	:	:	:	:
PT	1 162	4 730	4 542	1 124	66	3 194	9 149	8 769	4 260
SI	913	2 022	1 882	908	42	2 787	1 797	1 537	807
SK	442	1 166	1 113	229	17	1 385	1 867	1 690	916
FI	1 289	28 816	17 401	7 398	92	5 155	12 453	11 722	5 142
SE	3 359	24 535	25 471	6 518	57	28 200	26 788	26 579	11 506
UK	11 404	92 178	80 451	32 958	77	133 935	182 970	175 744	93 210
BG	1 247	526	494	156	12	3 514	1 527	1 460	848
RO	1 610	922	830	327	11	9 598	3 278	3 054	1 691

EU aggregates are based only on the available country data.
Exceptions to the reference year: 2002: High-tech KIS in CY, high-tech manufactures in LT, LU, MT, PL and SE.
2001: High-tech manufactures in CY.

([1]) Total high-tech sectors include high-tech manufacturing and high-tech KIS sectors. Exceptions:
High-tech KIS only: EE, LV, LU, MT and NL.
High-tech manufacturing only: PL.

Source: *Eurostat, High-tech statistics*

Table 3.4 shows the distribution of the high tech manufacturing industries and of the high-tech knowledge intensive services in Europe. These economic activities are determined by a relatively high R&D-intensity shown in these sectors. For manufacturing these activities mainly concentrate in the large European Member states. This is to a certain extend also true for the high-tech knowledge intensive services (post and telecommunication, computer services or R&D). Member states such as Spain or the Netherlands are nevertheless also producing a considerable value added in these sectors.

There are some sectors which seem to become more R&D-intensive, such as certain market services (leisure & hotels, media & entertainment, health, software, internet) and biotechnology. These sectors may drive the world economy in the future, as has been the case with the ICT industry in recent decades. In some of these sectors, EU companies account for a relatively small share of R&D investment and sales compared to figures worldwide. R&D in services has grown rapidly, albeit from a low base in recent years. However, the horizon of R&D investment is typically much shorter than in manufacturing, as is the window for using R&D output.

3.2.2.2 Leveraging private research

There is a need to devote sufficient attention to private research when governments consider their priorities, especially as private firms are likely to relocate if the regulatory environment and incentives are not appropriate.

Competitive and innovation-friendly environment

Research policy has long been focussed on supporting academic research, whilst offering some top-up funding to selected industries (in the form of State aid). Over time, new funding instruments have been introduced, such as tax incentives, loan guarantees, reimbursable aid, or support to VC funds. Although it was recognised that there is a relation between research policy objectives and other policy areas (intellectual property rights, innovation, product market regulation, etc.), policy agendas have evolved separately, with little interaction occurring between them. The resulting 'policy aggregates' fall short of constituting an appropriate policy mix addressing national research objectives efficiently. This would require starting from the definition of a consistent set of policy objectives spanning the whole range of policies involved in the innovation system, and the assessment of the different policy paths which could lead to these objectives. This approach involves a large coordination effort among policy-makers in the different fields and the systematic use of commonly agreed assessment tools. The establishment of integrated guidelines and National Reform Programmes (2005-2008) in the context of the re-launched Lisbon strategy is a first step in this direction, but more needs to be done during the period ahead (2008-2011).

A competitive environment encourages companies to acquire new knowledge and know-how in order to gain or retain a competitive edge in their core and related markets. Insufficient investment in R&D and innovation – in comparison with other regions (e.g. US, Japan) – could be the sign that market actors enjoy, at least partially, monopolistic benefits.

The Community framework for state aid for R&D and innovation

Effective State aid control is key to ensuring more competitive markets and to creating appropriate incentives for investing in R&D and innovation. The new 2007 Framework for State Aid for R&D and innovation sets the principles for allowing aid to public institutions and private companies. Its recent revision will help better address new forms of public private cooperation and at the same time focus control on the potentially most distorting situations. This was necessary since research institutions have increasingly acted as private undertakings in domains bordering market activity, making State aid issues more relevant for them.

Opportunities for procurement of R&D services

The opportunities for procurement of R&D services currently seem to be not known or underused at the MS level. Therefore the Commission is exploring the possibility of clarifying how Member States can use procurement of R&D services as a driver to stimulate innovation.

Intellectual property right (IPR) issues

In today's knowledge economy, intangibles, in particular R&D results, are often the main assets of many organisations, especially industrial and technology-based companies. As each R&D result is a piece of intellectual property (whether or not it is protected by formal IP rights such as patents), the regulatory IPR framework directly affects the research performers and users, and their interactions. Experience shows that the quality of the IPR framework is one of the factors influencing investment decisions, especially regarding technology-related investments, and indeed the attractiveness of a number of emerging countries has increased thanks to sets of measures including reforms of their IPR legislation.

There has been significant progress in recent years with the creation of the European patent, the Community trademark, the Community design, and through harmonisation of several aspects of copyright and related rights legislation, to name but a few. However, users are still calling for improvements to the patent and copyright systems related in particular to cost and legal certainty issues.

This is clear from the answers provided to the two public consultations recently conducted by the European Commission's Directorate General Internal Market and Services (one on the 'Future patent policy in Europe' (16/1-12/4/2006), complemented with a public hearing on 12/7/2006, and another one on a 'future Single Market policy' (11/4-15/6/2006), in which a number of IPR issues were also discussed).[122]

The European patent system has been available since 1978, and makes it possible to protect an invention in up to 36 countries.[123] It is highly successful despite some drawbacks such as high cost (due in particular to burdensome translation requirements) and limited legal certainty.[124]

To address the main drawbacks of the European patent, the Commission proposed in 2000 a Regulation on a Community patent system (COM(2000)412) which would be unitary even in the post-grant phase. This would bring much more legal certainty, namely through the setting up of a unified jurisdictional system. However, the contents of the March 2003 'common political approach', and in particular its translation requirements, would reduce translation costs by only about 50% (from approximately €10,200 to €4,845), and would lead to global savings of at most 20%.[125] This is clearly insufficient as it is considered that the current European patent is from 3 to 8 times more expensive than a US patent, depending on the parameters used (although this does not reflect the fact that several separate filings are sometimes required to protect in the US an invention which could have been protected by filing a single European patent application).[126] Unfortunately, discussions on the Community Patent are currently in deadlock.

Two separate initiatives have been proposed by a number of Member States and the EPO: the London Agreement (to reduce translation requirements) and the European Patent Litigation Agreement (EPLA) to create a new centralised court for patent litigation, increasing legal certainty).[127] However, a number of issues need to be solved before either initiative can proceed.

In addition to these patent initiatives, a number of specific R&D-related issues may also need to be addressed. In particular, European academics are calling for the ability to access research data more easily (the 'open access' movement).[128] This global initiative calls for research data

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[122] See http://ec.europa.eu/internal_market/strategy/docs/report-from-consultation_en.pdf, http://ec.europa.eu/internal_market/indprop/docs/patent/hearing/preliminary_findings_en.pdf

[123] Including all EU MS – see http://www.european-patent-office.org/epo/members.htm

[124] Claims of a European patent need to be translated into FR, EN and DE, and once granted patents need to be translated in all of the languages of the countries designated on the application form before they are valid. Furthermore, it is estimated that only about 2'% of the translations of European patents are ever consulted by anyone. Due to the fact that, once a European patent is granted, it becomes a bundle of national patents totally independent from each other, requiring in certain cases to conduct litigation separately in different countries, with possibly different outcomes.

[125] See http://register.consilium.europa.eu/pdf/en/03/st07/st07159en03.pdf
According to the Commission's estimations
See http://ec.europa.eu/internal_market/indprop/docs/patent/compat_costs_en.pdf

[126] See "*The cost factor in patent systems*" by Bruno van Pottelsberghe and Didier François – CEPR discussion paper No. 5944 – http://papers.ssrn.com/sol3/papers.cfm?abstract_id=954607&download=yes

[127] See http://patlaw-reform.european-patent-office.org/london_agreement/index.en.php, http://patlaw-reform.european-patent-office.org/epla/index.en.php

[128] See http://www.soros.org/openaccess/

and publications to be made available to researchers more rapidly and readily. However, unlike in US patent law, European law does not have a 'grace period' and thus our inventors cannot publish/discuss details about their inventions before they file a patent application.[129] This means that, if a European inventor submitted an article for publication and then discovers that the invention is actually commercially valuable, he has only about 3 months to figure out its practical applications, check reduction to practice with a few examples and file for patent protection. The net result is that inventors may need to suspend all his/her other duties or to delay publication in order to concentrate on the challenge, and it is hard to motivate someone to do so. This puts European researchers at a competitive disadvantage in comparison to their American counterparts. The European academic community has been calling for years for such a provision to be implemented.[130] However, it is broadly accepted that this should happen only in the context of an international initiative about the harmonisation of patent law.

Furthermore, copyright law is also under scrutiny, especially due to the new challenges that digital media has created. Digital rights management (DRM) technologies are currently being used by publishers and copyright holders to control access to digital works. However, they can often create barriers for access or discourage or eliminate uses that are authorized by law. Unfortunately, the development of technologies that protect copyrighted works has outpaced the development of technologies that both protect and permit legal uses of copyrighted works. This has meant that provisions which promote research and which are allowable under copyright law (e.g. the research exemption) are currently being undermined by the use of said DRM technologies.

Also important are the rules governing the ownership of university results. Almost 30 years ago, the US adopted the Bayh-Dole Act. This ground-breaking piece of legislation gave US universities the right to own all patents resulting from publicly funded research and give licenses. This experience has proven to have a number of drawbacks, especially as universities have struggled to keep a balance between the academic freedom and the commercialisation of research results. That said, it is generally seen as beneficial on two fronts – it gave the US a clear result ownership regime and it helped highlight the importance of exploiting research results, whilst giving universities sufficient autonomy to ensure that they could engage actively in such activities. In contrast, while most EU Member States currently apply an 'institutional ownership' regime, some still rely on regimes such as the 'professor's privilege', according to which public-sector researchers or professors may personally own their R&D results and the associated intellectual property rights. Furthermore, the question of whether 'European' publicly-funded research results should be primarily exploited in Europe remains open.

The enforcement of IP rights is of the utmost importance for European industry, and even for society at large, given the risks associated with the use of counterfeit drugs and spare parts for vehicles, for instance. Regarding enforcement in Europe, in addition to the above-mentioned initiatives (EPLA and the Community patent jurisdictional system – which are not mutually exclusive solutions), it is worth mentioning that a number of other legislative measures have been taken or proposed.[131] However, more serious problems have been identified abroad, namely regarding the enforcement abroad of intellectual property rights owned by European companies, especially in certain Far-East countries. In this respect, several issues need to be considered, including a poor local IPR awareness, inadequate or inadequately applied sanctions,

[129] In most countries where it exists (the US, Japan), the grace period is usually between 6 and 12 months.

[130] E.g. ProTon Europe, see http://www.protoneurope.org/Signup/041123minutesdublinag/attachment_download/file; See the "Grace period" section in http://ec.europa.eu/invest-in-research/policy/ipr_en.htm#2

[131] For instance Directive 2004/48 on the enforcement of intellectual property rights, a recent Proposal for a Directive on criminal measures aimed at ensuring the enforcement of intellectual property rights (COM(2005)276), and Regulation 1383/2003 concerning customs action against goods suspected of infringing certain intellectual property rights and the measures to be taken against goods found to have infringed such rights

the difficulty for European companies to identify counterfeiting activities taking place abroad, limited knowledge of European companies regarding non-European IPR systems, etc.

3.2.3 Human resources

Human resources are at the heart of knowledge creation, transfer and exploitation. This section reviews where Europe is in terms of the availability of researchers and their training, mobility, (intra- and extra-EU) and career development.

Researchers in Europe

The number of researchers in full time equivalent (FTE) per thousand labour force amounted to 5.4 in the EU in 2003, compared to 10 and 9 in Japan and the US respectively and remains essentially unchanged since 1999.[132] At Member State level the picture is quite varied, with sometimes considerably lower figures in 15 Member States, while a handful of Member States show a figure close to or above those for Japan and the US.

Nonetheless, the number of researchers per 1000 workforce in the EU has been growing at an average annual rate of 2.8% between 1997 and 2003. Only few Member States showed a negative or slow growth rate. Data for 2004 show that the share of researchers in the workforce is slightly up (+ 3.5%) compared to the past average.[133]

The deficit in the share of researchers of the workforce as compared to the US and Japan is mainly located in the business sector. Of the estimated total of 1,180,000 researchers (FTE) in the EU-25 in 2003, about 50% were employed in the business sector. This compared to some 68% in Japan and about 80% in the US.

EU countries still produce more science and engineering graduates and train more researchers for a doctorate than the US and Japan. Strong imbalances within national labour markets mean that in a number of EU countries many graduates find better employment and career prospects in other economic sectors. In fact, the EU shows some serious levels of unemployment among researchers, and the lower salary levels of researchers in comparison with other employment-sectors would seem to indicate that there is no shortage of researchers either.[134]

Imbalances between national labour markets also cause a drain of researchers to other countries, including outside the EU, in particular to the US. Although an estimated 80,000 to 100,000 EU-born researchers (in head-count) are active in research in the US, this only amounts to some 5% to 8% of the total EU researchers' population. Set against the concept of a beneficial 'brain-circulation', such a contingent of internationally mobile researchers would even be desirable if there was a clear prospect that a large portion of this group would (eventually) return to the EU. However, a majority is reluctant to return because of a lack of attractive research and career prospects.

At the same time a decline of the share of S&E graduates in the EU and the ageing of a significant portion of the S&T workforce is a growing concern in many Member States. Women also remain seriously under-represented among both researchers and S&E graduates.

[132] Unless otherwise stated the data in this section are from the DG Research publication 'Key Figures 2005'.
[133] Eurostat report 'Science, Technology and Innovation in Europe', 20 November 2006.
[134] European Commission, 2007, 'Study on the Remuneration of Researchers in the Public and Private Commercial Sectors'.

A bottleneck is the lack of a comprehensive data-system on researchers' career paths and mobility patterns. Although projects aiming at establishing such a system are underway, available data are still incomplete and lacking in comparability.[135]

Mobility and career development

Mobility plays a crucial role in establishing a European labour market for researchers. It is crucial for a more effective knowledge sharing throughout the EU, while it adds at the same time to career opportunities and career development of researchers. It would also contribute to stabilising labour markets imbalances within the EU, if mobility at intra-European level was to be more easy and advantageous than mobility to countries outside the EU.

So far, improvements on intra-European trans-national mobility have been poor in both the public and the private sector. Indications are that up to now yearly only around 5% of doctoral candidates and at maximum 10% of the researchers at post-doctoral level undergo an intra-European mobility experience.[136]

National systems are still very reluctant to respond actively to what has been proposed at European level. Research organisations are often more than reluctant to see 'their' researchers leave to acquire or share knowledge elsewhere, considering it as a loss of resources. Researchers do not want to lose potential job opportunities in their current organisational environment, while researchers' employers generally recruit from within their local environment.

Inter-sectoral mobility, in terms of two-way flows between private and public sector, is also still very much underdeveloped, even though a more systematic and natural mobility between sectors is considered crucial for eradicating at least in part the so-called European paradox. Hampering factors are predominantly cultural issues on both sides, as well as practical issues, for instance related to pension build up.[137]

For mobility in general, various regulatory obstacles, notably in the areas of social security and taxation, still seriously hinder a more frequent - if not structural - mobility throughout a researcher's career. These obstacles require concerted efforts at national level as they often fall outside EU competences. But as long as there is no comprehensive, systematic approach throughout the Union, the situation is not likely to improve significantly.

On the funding side of trans-national researchers' mobility, there is considerable potential for expanding the scope and impact of regional or national activities on trans-national human resources development. At European level, the 'Marie Curie Actions' - which under FP7 will be expanded considerably over time - contribute. In particular the 'co-funding of regional, national and international programmes' is one concrete new FP7-financial incentive measure with a lot of development potential.

The European dimension of career prospects and recruitment issues has been identified as of crucial importance for a researcher's market to be appealing, rewarding and in fact function properly at national and European level. Many of the critical issues have been addressed in the European Charter for Researchers and the Code of Conduct for their Recruitment. By actually

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135 Of particular relevance is the ongoing joint OECD, Eurostat , and UNESCO project aimed at developing a regular and internationally comparable production system of indicators on the careers and mobility of doctorate holders.

136 European Commission, 2007, 'Integrated Information System on European Researchers 2', DG JRC-IPTS. http://www.jrc.es/home/pages/action_11302.htm

137 European Commission, 2006, 'Mobility of Researchers between Academia and Industry: 12 Practical Recommendations'. See http://ec.europa.eu/eracareers/pdf/mobility_of_researchers_light.pdf.

embracing the principles of the Charter and Code and acting upon them, employers and sponsors of researchers and Member States would create a competitive edge. And that if collectively applied throughout the EU, Europe would become a lot more attractive to the best researchers Although so far quite some research organisations in Europe have signed up to the Charter and Code, this is simply insufficient taking into account the number of actors addressed.

Training of researchers in Europe

Modern generations of researchers need training and skills development commensurate with a knowledge-based economy and society. A hampering factor for more inter-sectoral mobility is that researchers often do not have the required combination of knowledge and skills to move to a private research environment.[138] Closely linked with the Bologna process, measures are beginning to be implemented to improve the training curricula, although a comprehensive EU-skills agenda still seems a far way off.[139] Through FP7, measures to structure, combine and thereby raise the overall quality of the initial training offer for researchers throughout the EU are being stepped up, including but not exclusively targeted at doctoral programmes.

It is however not only new generations of researchers that need to acquire a combination of cutting edge knowledge with a multi-disciplinary approach and soft-skills to be able to more fruitfully contribute to the application of research. The concept of systematic life-long training, with attention to individual competence diversification, in terms of skills acquisition at multi- or interdisciplinary level, still needs to be mainstreamed throughout the EU. The action-line 'Life-long training and career development' in the FP7 people programme serves as an example, while the programmes to be operated by the European Research Council are also expected to contribute.

International dimension

In addition to the notion of an EU research career, the attractiveness of ERA to the best researchers world-wide is to be enhanced by the current EU-wide implementation of Community legal and accompanying measures for fast track visa and residence of third country researchers. However, the openness of the intended internal market for researchers could be even more beneficial for EU research, not only a systematic internal 'brain circulation', but also including third countries in that.

Although EU researchers are mobile outside the EU, few do so in the frame of a European career development, where they would apply for instance new knowledge back in the EU and exploit their international contacts for collaboration. The reluctance of many of these researchers moving outside the EU to return is increasingly being addressed by specific return and reintegration measures at national and European level. This is accompanied by efforts to network these researchers abroad, in order to keep them in touch with developments in the ERA, with a view to a possible return or at least in order to facilitate international collaborative research links outside Europe.

Reciprocal measures are also emerging to bring top-class researchers into the ERA, so as to reinforce the EU research effort. Networking such researchers in the EU, by keeping them in touch with each other and with their regions of origin, is beneficial for both EU research and for research in the region of origin, in terms of collaborative international links.

[138] Ibid.
[139] DOC-CAREERS project by the European University Association, see http://www.eua.be/index.php?id=106.

3.2.4 Stakeholder's roles and interactions

A few decades ago, research was conducted in research institutions and then applied in industry. Nowadays, the landscape is much more complex, with research being carried out in industry as well as in research institutions, and transferred to potential users in a number of ways, including licensing and the creation of spin-offs by universities.

Moreover, R&D sponsors tend to have an increasingly important role, and different categories thereof need to be considered: public authorities, industry, financial institutions (e.g. the European Investment Bank's 'technology transfer accelerator' scheme), foundations, etc.[140] Often, these sponsors will to be involved in the governance of the institutions or projects they are funding.

The increasing number of stakeholders involved makes it clear that interactions between them become much more intense and complex than in the past. Moreover these interactions tend to extend beyond national borders, which adds a new dimension to the issue. Cross-border interactions clearly need to be promoted, as opportunities are evidently more numerous at European level than at local scale.

Interactions are also made much more intense than in the past as a consequence of new phenomena such as the 'open innovation' approach, under which industrial companies, in particular, do no longer rely exclusively or predominantly on their internal resources to fulfil their R&D needs, but also involve, where appropriate, customers, suppliers, and competitors, in addition to academic institutions, as sources of input. Moreover, companies are much more open to transferring their output not only to their customers but also to other third parties, and even to spinning-out some of their output, i.e. to create new companies which may eventually become autonomous.

This is for instance reflected in patent data. As stated in the *OECD* Science, Technology and Industry Scoreboard 2005: "*In 1999-2001, 6.7% of all patents filed at the European Patent Office (EPO) were the result of international collaborative research*".[141]

This OECD document goes on to state that "*For most European countries, however, the level of collaboration with US inventors and inventors from the main EU country is similar. For example, 15.0% of French patents have foreign co-inventors, of which 4.3% are from the United States and 4.1% from Germany (the main EU partner country).*"

We can therefore surmise that European research is relatively well interconnected and that collaboration with researchers in third countries is considered to be no more advantageous than seeking intra-European assistance.

To further investigate these interactions, the following sub-sections address a number of closely interlinked issues: university-industry technology transfer processes, how to facilitate SME participation in such processes, relevant national initiatives in this area, and the new 'open innovation' environment.

Technology transfer/knowledge transfer

Existing European research and technology transfer infrastructures suffer from a major lack of critical mass. Most technology transfer offices (TTOs) have between five and ten full-time staff and generate three licensing deals and three spin-offs per year.[142]

[140] See http://www.eif.europa.eu/tech_transfer
[141] See http://miranda.sourceoecd.org/vl=5729877/cl=19/nw=1/rpsv/scoreboard/c08.htm

There is a high potential for development, but European universities do not have the ability to transfer their knowledge effectively and efficiently. This is caused essentially by factors related to the supply side such as the prevalent culture in the European public research sector which is weighted against commercialisation, the perceived bureaucracy, and excessive fragmentation on the demand side.

Currently no data relating to university-industry knowledge transfer are available for the whole EU, despite a number of national surveys. However two European surveys – carried out by ProTon and by ASTP amongst their member Public Research Organisations (PROs) – can be used to make a rough comparison between Europe and North America (AUTM Survey).[143] In order to make comparisons, it is useful to standardise measures given in the surveys (per million PPP€ or $ of research expenditure, per number of researchers in terms of time devoted to research) as was done in the ASTP survey where a standardised comparison of European data and AUTM data is provided.[144]

Table 3.5: University-industry knowledge transfer – a comparison between the US and EU

	EU (ASTP)	US (AUTM)	Ratio
Average research exp. (million US$)	*156.4*	*214.6*	
Invention disclosures	0.305	0.407	0.75
Patent applications	0.121	0.255	0.47
Patent granted	0.057	0.089	0.64
Licenses executed	0.134	0.115	1.17
Start-ups established	0.016	0.011	1.45

Source: The table is a compilation of the ProTon and ASTP surveys.[145]
Note: Figures given relating to invention disclosures, patent applications, etc. are all per million PPP$ of R&D expenditures

These comparisons show that the surveyed European institutions lag behind North America regarding invention disclosures as well as patent applications and grants (by 25%, 53% and 36% respectively), which seems to indicate a lower level of efforts to commercialise public R&D in Europe. On the other hand, Europe performs better than the US regarding licences granted and start-ups established (the surveyed European institutions outperforming North American ones by 17% and 45% respectively). This suggests that despite less effort, Europe is relatively successful regarding the actual use of public R&D results by the business sector. However, the latter two indicators do not take into account the long-term success of start-ups (as the survey recognises) nor the amount of licensing revenues, which may well be less favourable to Europe, as other sources suggest.

In 2006, DG RTD conducted a public consultation on knowledge transfer which confirmed that there appears to be an urgent need for concrete guidance to facilitate links between industry and

142 2nd Annual Survey by ProTon, 2004
143 http://www.protoneurope.org/news/2006/art2006/artjanmar06/2asfy2004/attachment_download/file, http://www.merit.unu.edu/publications/docs/200605_ASTP.pdf, http://www.autm.net/events/File/FY04%20Licensing%20Survey/04AUTM-USLicSrvy-public.pdf
144 Purchasing power parities, according to OECD data.
145 http://www.protoneurope.org/news/2006/art2006/artjanmar06/2asfy2004/attachment_download/file, http://www.merit.unu.edu/publications/docs/200605_ASTP.pdf

research institutions, focussing especially on actions which must be undertaken by public authorities and the stakeholders themselves.[146]

Furthermore, according to a study undertaken by the European Investment Fund (EIF), there is a clear market failure in the area of technology transfer, linked to the considerable weakness of early stage venture capital in Europe.[147] In particular, the duration of publicly-funded financial vehicles is often too short.

The EIF has observed that the results of European research are often not commercialised to their full potential and to the same extent as in other regions of the world, in particular the US. Furthermore, Europe's technology transfer is mainly a national issue, with the fragmentation of European technology transfer offices, working primarily on a local level, without significant interaction between them or with other European counterparts. This is deemed to create a fertile ground for non-European operators to poach European ideas for exploitation elsewhere.

European universities' technology transfer offices are less staffed, less professional and less equipped compared with their US counterparts. In addition, there is a lack of appropriate pre-seed financial instruments to validate new technologies, assist universities in filing patent applications and finding the first customers for academic research results, as venture capital is largely absent from the pres-seed phase, for structural reasons.

The lack of critical mass for TTOs in Europe is also relevant when the offices are too diluted over too many technologies. While critical mass remains mainly unaddressed in a number of institutions, solutions seeking to create critical mass are sometimes implemented, such as combining research capabilities across research institutions (this is the case of the VIB, the *Flanders Institute for Biotechnology*, grouping nine biotechnology laboratories from several Flemish universities), or combining technology transfer functions across several institutions.[148] An example of this is the SetSquared Incubator, which is jointly operated by the Universities of Bath, Bristol, Surrey and Southampton in the UK.[149] This is, however, very rare.

SMEs' specific needs for knowledge transfer

The diversity, complexity and time to payment of the different small and medium sized enterprises support mechanisms available at national level are crucial factors determining whether they are used or not.

Many Member States have introduced (or are planning to) specific R&D tax incentives or voucher schemes (see the Netherlands for example) to simplify support to SMEs and in particular Young Innovative Companies.[150] Tax incentives delivered in the form of wage tax reductions for research personnel have the added advantage of providing up-front support (it is not a reimbursement) and benefit all companies. Vouchers allow SME to establish a first contact with a public research performer, and have great behavioural additionality potential. The real challenge, however, lies in providing simple and useful information regarding all the different funding opportunities available, permitting an SME to assess its options. It is a matter for each Member State or region to facilitate access to such information and thereafter to simplify application procedures.

In order to attract SMEs to the technology transfer process in Europe, it is important to recognise that companies will only invest in innovation and R&D if they have access to

[146] See http://ec.europa.eu/invest-in-research/pdf/download_en/consult_report.pdf.
[147] 'The Technology Transfer Accelerator' by European Investment Fund (EIF) on behalf of the Research Directorate-General of the European Commission – http://www.eif.europa.eu/tech_transfer.
[148] www.vib.be.
[149] www.setsquared.co.uk.
[150] A definition of YIE is provided in the new Community framework for State aid for R&D and innovation.

appropriate funding and a reasonable assurance that they will be able to reap the rewards of that investment. The lack of funding will primarily affect 'peripheral' (non-core) activities of SMEs, such as R&D and knowledge transfer, but also their ability to acquire new knowledge and translate it into marketable products or services. There are marked differences in the role of venture capital in the US and Europe. These are particularly highlighted in a recent paper by the European Commission.[151] The returns for early stage funds is also an area for concern since, over a 20-year period, these have been 19.1% in the US vs. only 1.9% in Europe.[152]

Table 3.6: Venture capital (VC) investment in technology – US and EU (2003)

	US	EU	Ratio
VC investment in technology, € billion	13.7	3.1	4.4 times
Number of companies	2 208	4 354	0.5 times
Average investment, € million	6.2	0.7	8.9 times

Source: European Commission, DG ECFIN, 'The profitability of venture capital investment in Europe and the US', ECFIN/L/6(2004)REP/50386, Brussels, 28 September 2004.

National knowledge transfer initiatives

In recent years, a number of Member States have taken valuable policy initiatives to facilitate relations/knowledge transfer between research institutions and industry, in the perspective of promoting the actual use of publicly-funded R&D results and the associated socio-economic benefits.

Such initiatives include:

- ✓ The development and implementation of guidelines or model contracts at a national level**,** e.g. the Irish 'National Code of Practice for Managing Intellectual Property from Publicly Funded Research' (and 'Code of Practice for Managing and Commercialising IP from Public-Private Collaborative Research'), the UK 'Lambert Agreements' for PRO-industry relations, or the Danish document on 'Contacts, Contracts and Codices', all developed around 2004 (other guidelines are less recent, for instance the French ones, developed in 1999).[153] Such common principles and/or model contracts are intended to reduce the 'transaction costs' of research institution-industry relations, by offering an accurate starting point for negotiation, etc. Some of these initiatives have prompted similar ones in other countries.
- ✓ Changes in national legislation, including in particular the abolition of the 'professor's privilege' regime in several countries (including Germany in 2002).[154] As a consequence of

[151] European Commission, DG ECFIN, 'The shifting structure of private equity in Europe – What role for the early stage investment?', ECFIN/L/6(2005)REP/51515, Brussels, 31 March 2005.
[152] European Commission, DG ECFIN, "The profitability of venture capital investment in Europe and the US', ECFIN/L/6(2004)REP/50386, Brussels, 28 September 2004; EVCA; Thomson Venture Economics.
[153] See http://www.forfas.ie/icsti/statements/icsti040407/index.html, http://www.sciencecouncil.ie/reports/acsti051125/acsti051125_ip_code_of_practice_webopt.pdf, http://www.innovation.gov.uk/lambertagreements, http://billed.di.dk/wimpfiles/lores/image.asp?objno=/686201.pdf, ftp://trf.education.gouv.fr/pub/rechtec/technologie/charte.rtf.
[154] This was a very significant change for German universities. It was accompanied by supporting measures such as the setting up of regional Patenting and commercialisation agencies ("Patent- und Verwertungsagenturen" – PVAs) in each *Land*.

these changes, the ownership of publicly-funded research results now resides with institutions instead of individuals (researchers/professors), which provides for a more effective management and exploitation. This is a good example of spontaneous convergence of regulatory frameworks in different Member States. As concluded by CREST in their 2004 report, '*Institutional ownership appears to be emerging as the common practice worldwide*', in the sense that this regime is considered better able to promote the exploitation of publicly-funded R&D results.[155]

- ✓ The proposal to set up an '*Institute of Knowledge Transfer*', with as mission is to improve the skills and competencies of the growing knowledge transfer practitioner community.[156] It will provide a structured career path for those working in the sector and contribute to the professionalisation of the Knowledge Transfer sector (initially in the UK, then also possibly across the EU).
- ✓ The networking of national technology/knowledge transfer offices, as was done in Germany (PVAs – *Patentverwertungsagenturen* – Patent exploitation agencies) and as is planned in Sweden.[157]
- ✓ However, these initiatives were usually taken from a purely national perspective. As a consequence, even if they may be beneficial at the national level, they do not reduce fragmentation at EU level, and sometimes increase it.

Open innovation: a new form of knowledge sharing

"*Organizations succeed by virtue of their ability to gain comparative advantage from the combined activities of competitors, suppliers, and customers; to obtain economic value also from intellectual property (IP) that is not needed for internal business purposes; to treat public research as a strategic resource; to spot and rapidly internalize discoveries from sources outside the company; and thereby to concentrate their own efforts on activities (such as improved service content) that best contribute to value creation and innovation for the company itself.*"[158]

Over the past decade, a growing number of companies have shifted from the traditional proprietary model, where internal R&D activities lead to internally developed products that are then distributed by the firm, to the open innovation model.[159]

In the Open Innovation model, high quality, useful knowledge is considered to be available from external sources and even the most capable and sophisticated company needs to be connected to these sources of knowledge. Moreover, open innovation is by definition related to the creation of networks between innovating companies and other organisations. In particular, companies are increasingly forced to team up with other parties (customers, suppliers, research institutions, etc.) to develop or absorb new technologies, commercialise new products, staying

[155] See http://ec.europa.eu/invest-in research/pdf/download_en/crest_report_barcelona_research_investment_objective.pdf.

[156] See http://www.ikt.org.uk.

[157] From *ResearchResearch*: "Sweden's 14 university technology transfer offices should be restructured along common lines to increase their efficiency. And this should be funded by a 60 million kronor (6.6m euro) reserve already earmarked for the purpose, says Peter Nygårds, industrialist and former trade and industry minister, who was asked to review Sweden's technology transfer office system for the Ministry of Education and Research."

[158] Dearing, A, (19 Jan 2007) 'Enabling Europe to Innovate', Science Vol 315.

[159] Chesbrough, H., (2003), 'Open Innovation: the New Imperative for Creating and Profiting from Technology', Harvard Business School Press; Chesbrough, H., (2005) 'Open Innovation: a New Paradigm for Understanding Industrial Innovation', in Chesbrough, H., Vanhaverbeke, W., West, J., eds., (2006), 'Open Innovation: Researching a New Paradigm', Oxford University Press.

on the edge of technological developments and create customer value, especially in sectors relying on multidisciplinary technologies, which can rarely be developed by a single player.[160]

Table 3.7: Technology balance of payments per country

Data 2003	Payments ($ million current)	Receipts ($ million current)	Payments as a % of GERD
Japan	4,862	13,043	3.6
US	19,033	46,988	6.5
UK	10,449	23,539	32.3
Canada	881	1,721	5.1
France	3,233	5,188	8.3
Norway	1,203	1,542	31.2
Finland	1,625	1,681	28.8
Germany	23,267	22,957	37.8
Switzerland (2004)	4,793	4,559	69.8
Italy	3,794	3,108	22.8
Portugal	742	401	64.5
Czech Republic	556	190	48.7
Mexico	608	54	21.9
Poland (2002)	1,044	246	94.3

Source: OECD, Main Science and Technology Indicators, 2006

The acquisition of patents, licenses and know-how from foreign companies is one way for a purchaser to obtain essential technological knowledge from third parties. This corollary for open innovation can be measured using the OECD-developed 'Technology Balance of Payments′ (TBP) indicator, which looks at international flows (inflows and outflows) of technology (industrial property and know-how – copyright and software being excluded).[161]

[160] Vanhaverbeke, W., (2005) 'The Inter-organizational Context of Open Innovation', in Chesbrough, H., Vanhaverbeke, W., West, J., eds., (2006) 'Open Innovation: Researching a New Paradigm', Oxford University Press.
[161] OECD, Oslo Manual; Frank, S., 'R&D and internationalisation', Eurostat 2006.

It is important to clarify that the Technology balance of payments (TBP) has several limitations for international comparisons as data may be distorted due to incompatible national sources, inappropriate samples, different methodology for the four main categories of TBP operation, etc.[162] However, by considering countries' trends over time we can use this data in order to draw some basic conclusions.

A preliminary analysis of OECD data (see Table 3.5) seems to show that there is a consistent pattern in the EU - most Member States have a quite balanced TBP, except for the UK which is a strong exporter and new Member States which are strong importers. The balance reflects the country's ability to sell its technology abroad on the one hand, and its use of foreign technology on the other. A deficit may be the result of increasing imports or declining receipts.[163]

If we consider the trend of TBP payments' over time we see that most countries show an increase: international technological outsourcing seems to have become an important source of new technological knowledge. The increasing complexity of most modern technologies and the shift towards an open innovation system make it quasi-impossible for a single country to develop all of them without relying on contributions generated abroad, which therefore requires more intense trans-national knowledge transfers. Companies are taking advantage of the opportunities offered by emerging international markets for technological knowledge to complement their internal R&D efforts: they combine external technology with internal competences and formal research activities (however, internal R&D remains crucial for the capacity to absorb external inputs).

3.2.5 Highlights

- ✓ **Research organisations**
  - o The EU's renewed Lisbon strategy is designed to promote growth and jobs, putting strong emphasis on increasing knowledge and innovation for growth. Construction of a knowledge-based society, building on foundations such as a European Higher Education Area and a European Research Area, should create a particularly attractive environment for Europe's universities and create opportunities that extend beyond the Bologna Process and even beyond Lisbon.
  - o Universities currently lack the attitudes, resources and propitious environment to enable them to respond fully to these challenges. Consequently, this reduces their capacity to generate high standards of cutting-edge research and prevents them from becoming powerful catalysts for innovation. The potential of European University-based research is thus underused.
  - o Without a change of attitude and the necessary reforms European universities will not face up to the challenges nor will they initiate and implement the changes needed. The end result should be excellence in the whole system, with European universities more responsive to the needs of society and economy.
  - o Member States and other public authorities, as well as universities themselves, are called upon to actively engage in this process:
    - ▪ Universities may need to be given real autonomy that allows them to become innovative and responsive to change. Member States should guide the university sector as a whole through a framework of general rules, policy objectives, funding mechanisms and incentives for education, research and

[162] Frank, S., 'R&D and internationalisation', Eurostat 2006.
[163] Frank, S., 'R&D and internationalisation', Eurostat 2006.

innovation activities. In return for being freed from over-regulation and micro-management, universities should accept full institutional accountability to society at large for their results.

- Universities may need to develop institutional strategies, make strategic choices and conduct internal reforms to extend their funding base, enhance their areas of excellence and develop their competitive position; structured partnerships with the business community and other potential partners will be indispensable for these transformations. In this strategy a European dimension offers the potential benefits of larger scale operations greater diversity and intellectual richness of recourses, plus opportunities for cooperation and competition between institutions.
- European universities may need to fully appreciate the importance of innovation and make it an integral part of their mission. In other words, universities' commitment to serving the public interest needs to be reconciled with competitive pressures - and the interests of the business community. With stronger, structured partnerships with business, European universities can deepen their regional links. As well as helping drive regional development; these partnerships benefit the universities themselves. Key points may be emphasised:

✓ **Private research**

- Two thirds of all European R&D is conducted by the private sector, and is concentrated in a very limited number of large companies. However, Europe still lags behind the US and Japan in terms of business expenditure on research and development.The Service sector is becoming increasingly engaged in R&D, but it is unclear whether the same R&D support mechanisms can be used for both the services and manufacturing sectors.The European patent and copyright systems should be improved through the introduction of a more cost-effective and legally-certain intellectual property rights framework (for example, by introducing the Community Patent).The new Community framework for State Aid for research, development and innovation asks research institutions to separate their costs and revenues for economic and non-economic activities, which can be addressed through the introduction of full cost accounting.The procurement of R&D services and innovative solutions is not always organised in a sufficiently transparent manner and opportunities are often lost when the processes fail to attract suppliers situated elsewhere in the EU.

✓ **Human resources**

- Since the setting out of the ERA-concept in 2000, an integrated strategy on human resources in R&D has allowed to achieve concrete results: more systematic analysis of obstacles to circulation and mobility, information/assistance to researchers, entry conditions for non-EU researchers), and career development initiatives (European Charter for Researchers and Code of Conduct for their Recruitment).
- However, major challenges still remain, such as:
  - EU countries train more researchers for a doctorate than in the US and Japan, although the EU has less researchers per 1,000 members of the active workforce. In many EU countries graduates find better employment and carer opportunities in other sectors. A majority of EU researchers working out of

Europe is reluctant to return because of a lack of attractive research and career prospects.

- Mobility: often research organisations are reluctant to see 'their' researchers leave, as this is considered as a loss of resources; if moving, researchers risk losing their contacts and pension rights; moreover, they can rarely move with their fellowships. A more systematic and natural intersectoral mobility, in terms of two-way flows between private and public sector is also still underdeveloped.
- Data: Europe lacks a comprehensive system of information on researchers' career paths and mobility patterns; practical usability of data is also hampered by a lacking overall definition of 'researchers' in Europe.
- Career: although an increasing number of research organisations is endorsing the Principles of the 'Charter & Code', very few have been put into practice measures aimed at ameliorating working conditions, career prospects and an open and objective quality driven selection of researchers.

✓ **Stakeholder's roles and interactions**

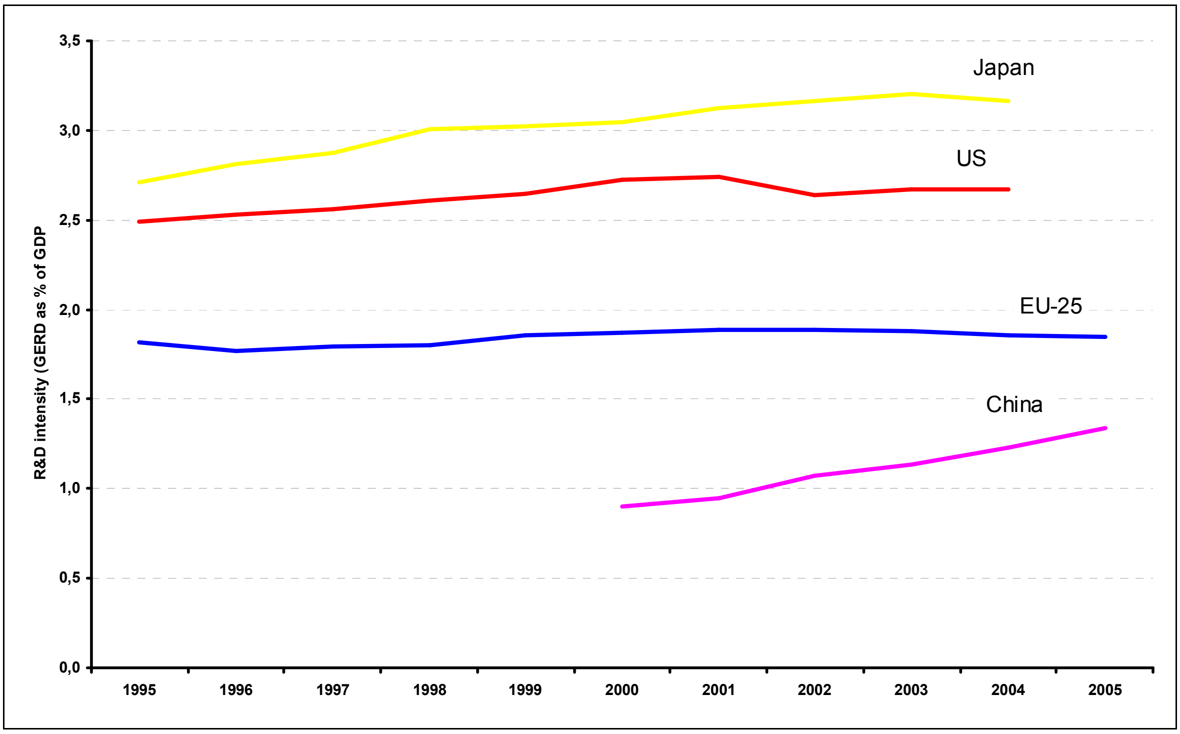
- General
  - There are insufficient interactions in R&D projects between stakeholder groups. This is increasingly important in today's knowledge economy.
- Public Research Institutions
  - European public research institutions still do not pay sufficient attention to the exploitation of research results.
- SMEs
  - SMEs' interest in innovative solutions / products depends largely on their capacity to absorb new knowledge, which must therefore be easily accessible and directly relevant to their core business (i.e. lead to an increased efficiency, a higher turnover or competitive advantages).
- Large companies
  - Large companies are increasingly engaging in 'open innovation' activities – they tend to collaborate closely with public research in a strategic manner and look to identify and internalize discoveries, permitting them to concentrate on core activities. This allows them to increasingly succeed by virtue of their ability to gain comparative advantage from the combined activities of competitors, suppliers, etc.

3.3 European Research: Efforts and performances

3.3.1 R&D expenditure and financing

The focus of this section is on the recent evolution of Europe's R&D financing and expenditure patterns since one of the 2000 ERA goals was to increase the funding for European research, in particular that coming from the private sector, which after the 2002 Barcelona European Council crystallised into the '3%' and 'two-thirds' objectives. This section will demonstrate that since 2000 not much progress has been made towards the '3%' objective, and that the absolute R&D expenditure gap with the US has not been reduced, while a similar gap is emerging with a small group of dynamic Asian economies. In addition, substantial amounts of R&D spending are flowing out of Europe. As a result, the EU's share in world R&D expenditure is under pressure. The prospects for R&D spending in Europe are not good. At the same time, the business sector is not visibly becoming more involved in the financing of R&D.

Figure 3.1: R&D intensity in the EU-25, US, Japan and China, 1995-2005



Source: DG Research Data: Eurostat, OECD Notes: (1) US: Break in series between 1998 and previous years: Japan: break in series between 1996 and previous years. (2) Japan: GERD was adjusted by OECD for the years 1991 to 1995 inclusive (3) China: Hong Kong is not included

R&D intensity

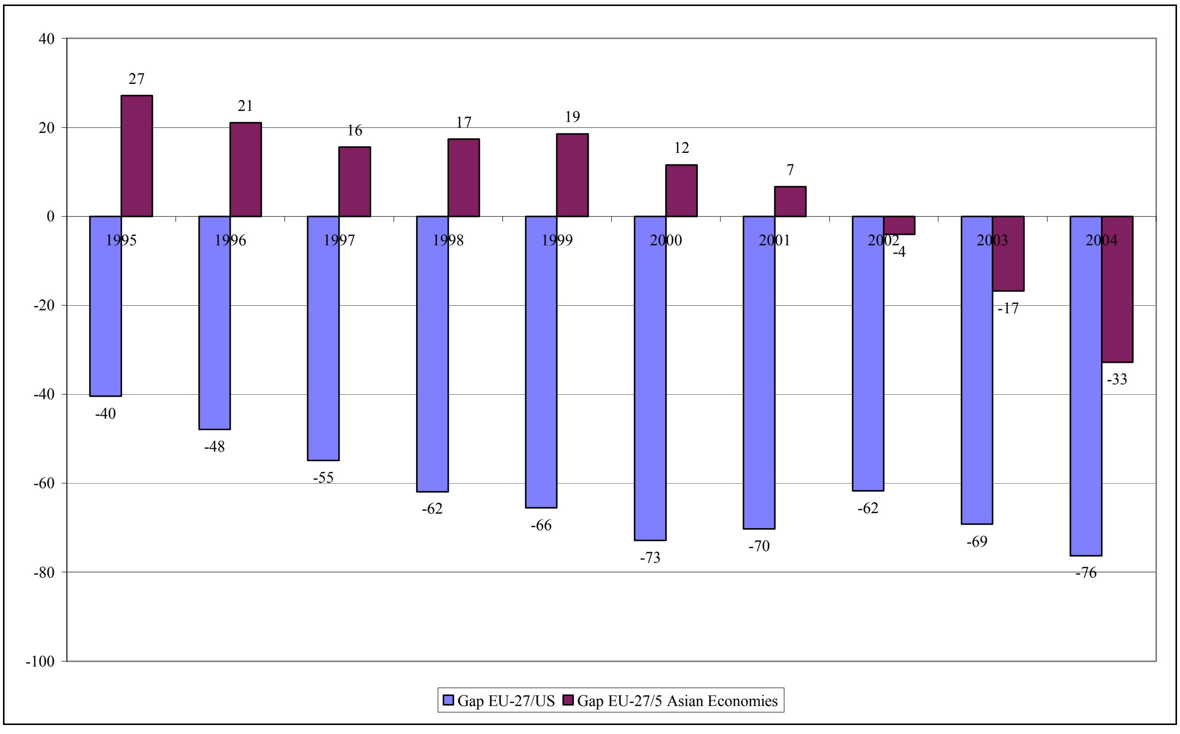
After a period of slow but continued growth between 1996 and 2002, the EU-25 R&D intensity has been slightly decreasing between 2002 (1.89%) and 2005 (1.85%) (see Figure 3.1). Since in the US, the downward trend has come to an end, the gap in R&D intensity between the EU and the US is increasing again since 2002. The R&D intensity in Japan has been growing faster than in both the EU and the US over recent years. If the current trend persists, China will have caught up with the EU-25 by 2009 in terms of share of GDP devoted to R&D.

An examination of the individual Member States' pace of progress after 2000, reveals a distinction between four groups of EU countries. A first group including the R&D-intensive countries Finland, Denmark, Austria and Germany, have been able to further increase their high R&D intensity and are pulling further ahead. Especially Austria has been able to progress very substantially over the recent years. France and Sweden experienced in the subsequent years a weakening of their growth performance and are now losing momentum. The new Member States Slovakia, Slovenia, Poland and Bulgaria, as well as Greece, and to a lesser extent Luxembourg, the UK, Belgium and the Netherlands are falling further behind since 2000. Conversely, most of the other new Member States, in particular Malta, Cyprus and Estonia, and to a lesser extent Spain, Ireland, Italy and Portugal, have been catching up with the EU average. At the same time, development gaps in terms of the production of scientific knowledge and technological innovation between EU regions, even between regions in leading Member States, remain substantial (see Eurostat data on R&D expenditure and personnel in the European regions). The European research landscape remains characterized by a high concentration of research effort in comparatively few Member States and, within them, in comparatively few regions.

Total R&D spending in Europe compared to the US and Asia

Between 2000 and 2004, the gap in real terms in total R&D spending between Europe and the US was not reduced, and in fact increased slightly. After 2000, a new R&D gap emerged between Europe and a small group of important Asian economies including China, Taiwan, Japan, Singapore and South Korea (see Figure 3.2).

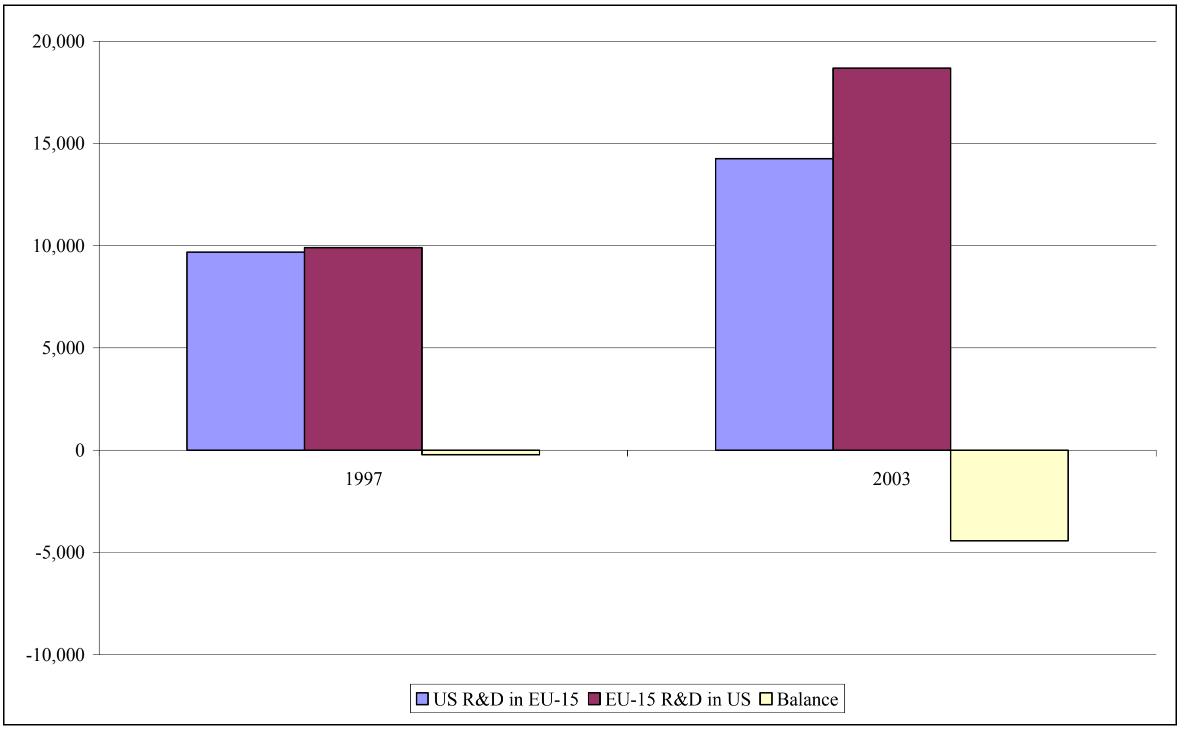
Figure 3.2: Gap in R&D expenditure (GERD) between EU-27 and US, and EU-27 and 5 Asian economies - in constant terms (million PPS, at 2002 prices) - 1995-2004[164]



[164] Constant prices refer to volume measures whose values are derived prices by applying to current quantities, prices pertaining to a specific base period. They allow figures to be represented so that the effects of inflation are removed. The values for each time period are expressed in terms of the prices in some base period.

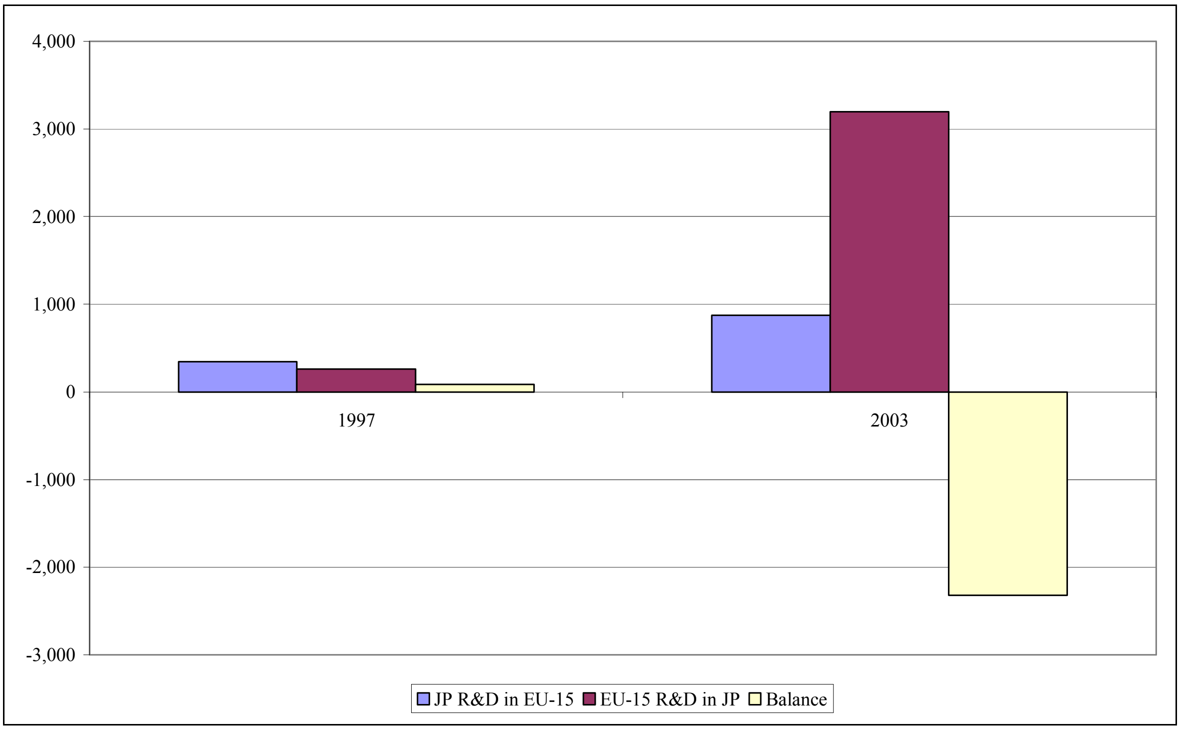
Source: DG Research
Note: 5 Asian economies: China, Taiwan, Japan, Singapore and South Korea

Figure 3.3: R&D expenditure flows between EU-15 and US, 1997 and 2003 (PPP$)



Source: DG Research
Note: R&D Expenditure by affiliates of foreign parent companies

Figure 3.4: R&D Expenditure Flows between EU-15 and Japan, 1997 and 2003



Source: DG Research
Note: R&D Expenditure by affiliates of foreign parent companies; these figures may be influenced by the merger between Renault and Nissan in 1999.

Triadic R&D expenditure flows

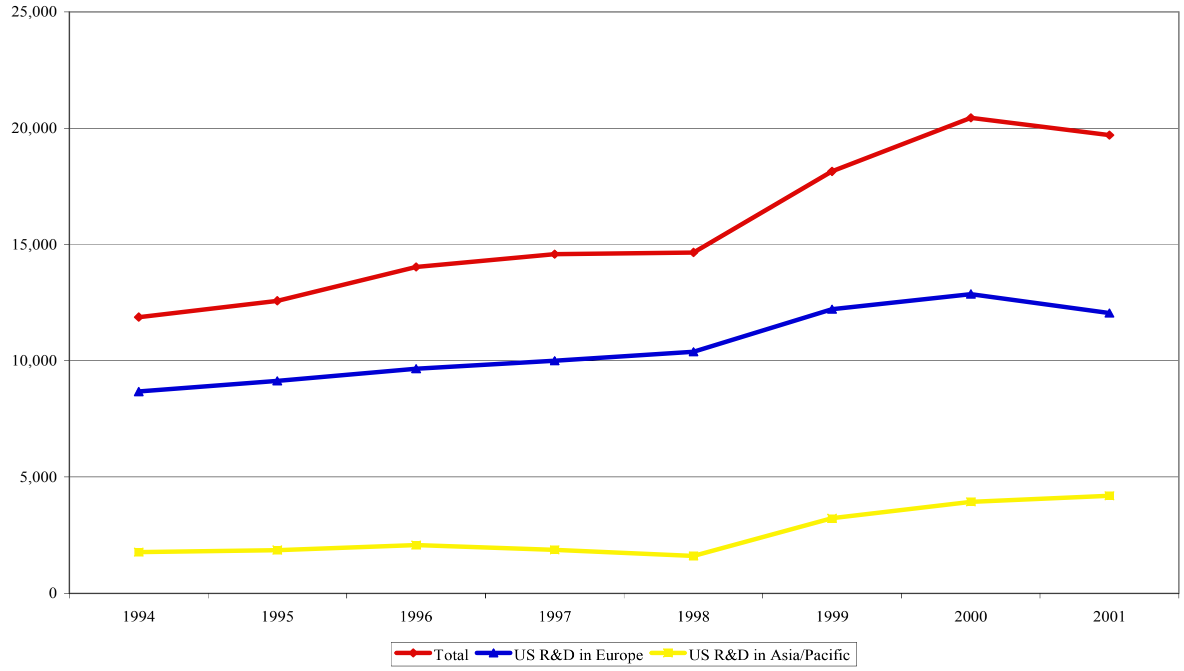
Substantial amounts of R&D spending are flowing out from Europe. Between 1997 and 2003, US R&D spending in the EU-15 increased from $ 9.7 to 14.2 billion PPP, while EU-15 R&D spending in the US increased from $ 9.9 to 18.7 billion PPP, turning a net outflow of $ 0.2 billion into one of 4.4 billion PPP (see Figure 3.3).

A similar story, though at a smaller scale, can be told for R&D flows between the EU-15 and Japan. Between 1997 and 2003, Japanese R&D spending in the EU-15 increased from $ 346 to 876 million PPP, while EU-15 R&D spending in Japan increased from $ 260 million to 3.2 billion PPP, turning a net inflow of $ 86 million into a net outflow of 2.3 billion PPP (see Figure 3.4).

R&D performed abroad by affiliates of US owned companies is shifting to other regions, especially to Asia (see Figure 3.5).

Figure 3.5: R&D performed abroad by majority-owned foreign affiliates of US parent companies, 1994–2001 ($ million current)[165]

[165] Current prices are the actual or estimated recorded monetary value over a defined period for a group of industries or products. They show the value for each item expressed in terms of the prices of that period.



Source: DG Research

The EU share of world R&D expenditure

According to OECD figures, the share of the EU-15 in the expenditure on R&D by all OECD member countries plus a set of non-OECD member countries (China, Chinese Taipei, Israel, Romania, Russian Federation, Singapore, Slovenia) dropped from 28% to 24% between 1995 and 2004.[166]

The prospects for R&D spending in Europe

The short-term prospects for R&D spending in Europe are not good. One piece of evidence is a recent survey among 200 multinational companies indicating as their home country the US (109 or 43.6%), a country in Western Europe (122 or 48.8%) or another country (19 or 7.6%). 7.2% of the respondents expected an increase in technical employment in the United States, while 11% anticipated a decrease in the United States. In contrast, only 3.3% anticipated an increase in technical employment in Western Europe whereas 16.7% anticipated a decrease. China and India were the main targets for expansion.[167]

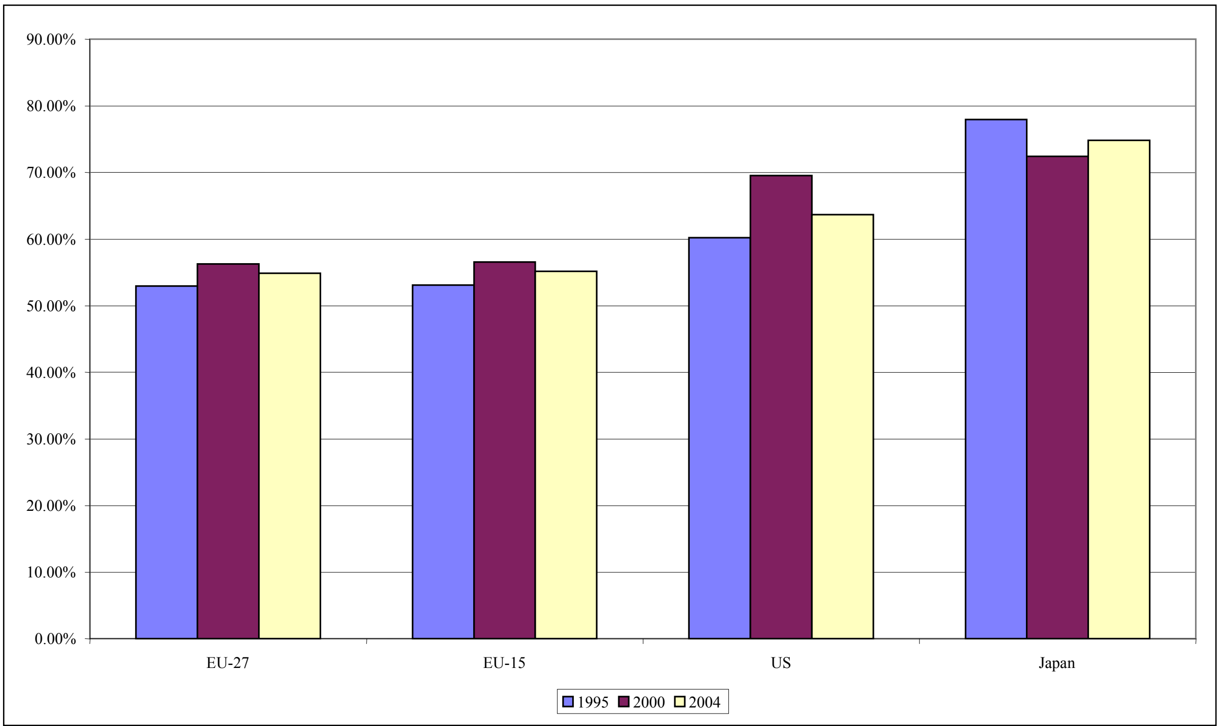
Trends in private and public funding of R&D

The EU is making little progress towards the 'two-thirds' objective for business financing of R&D and still lags behind Japan and the US (see Figure 3.6).

[166] OECD MSTI.

[167] Jerry Thursby and Marie Thursby, Here or There? A Survey on the Factors in Multinational R&D Location. Report to the Government-University-Industry Research Roundtable, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, Washington, DC, The National Academies Press, 2006.

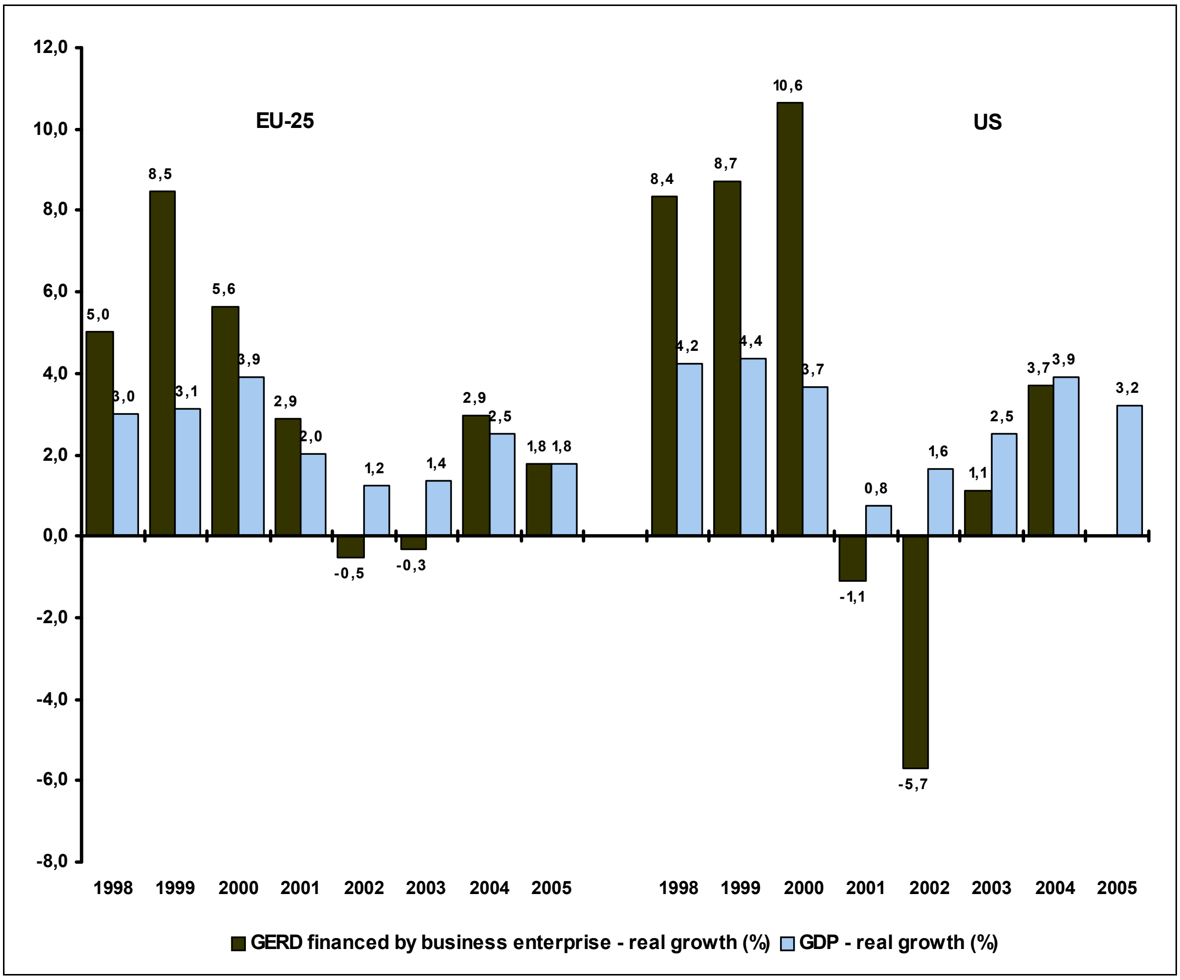
Figure 3.6: Share of GERD financed by business - EU-27, EU-25, US, Japan – 1995, 2000, 2004



Source: DG Research

Behind this apparent stagnation, however, sharp fluctuations in volumes of private investment are observed. Until 2000, the business funding of R&D grew at a very high rate, which even outpaced GDP growth (see Figure 3.7). This trend continued in 2001, even though growth weakened on both fronts. After 2001, the economic slowdown translated into a sharp reduction in the growth of business funded R&D. In 2002-2003, this growth was negative and well below the rate of GDP growth. A similar pattern was observed in the US, albeit with two noticeable differences. Firstly, growth of privately financed R&D was much more pro-cyclical. Its growth rates were two to three times higher than overall GDP growth until 2000, dropped more sharply than in the EU in 2001-2002, and experienced subsequently a stronger recovery from 2003 on. Secondly, there seems to be a one year time-lag between the EU and the US. The big fall of private investment growth occurred in 2001-2002 in the US whilst it took place mainly in 2002-2003 in the EU. Conversely, the recovery of both the economic growth and the business-funded R&D begun already in 2003 in the US, while in the EU-25, it took place only from 2004 on.

Figure 3.7: GDP and GERD financed by business enterprise in the EU-25 and the US: real growth per annum, 1998-2005



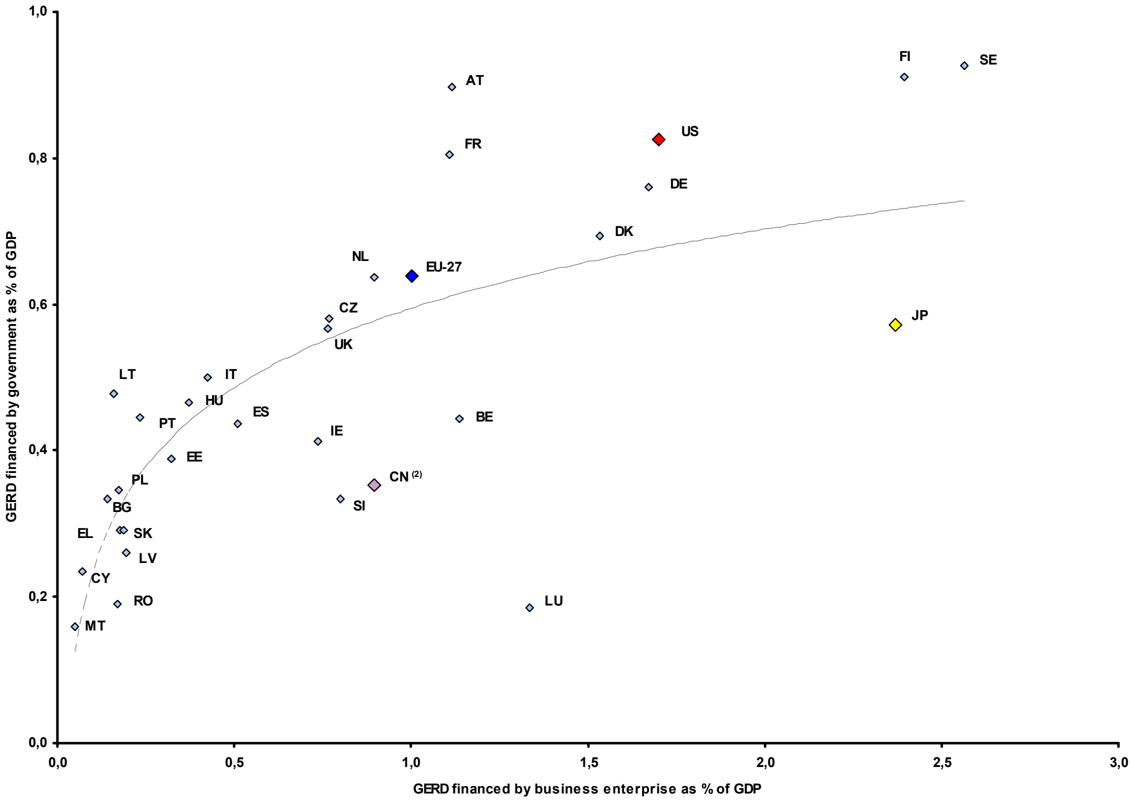
Data: Eurostat, OECD

Notes: (1) US: There is a break in series between 1998 and 1997 for GERD financed by business enterprise.

Although domestic R&D efforts are largely financed by the business enterprise sector in Europe, the US and Japan, the role of government in the financing of R&D should not be underestimated. The level of government-funded R&D intensity is substantial in many high R&D intensive countries (e.g. Nordic countries, Germany, France, Austria and the US), showing that high private involvement in the funding of R&D does not preclude government funding. Moreover, in low R&D intensive countries, government-funded R&D is higher than business-funded R&D. Government funding of R&D is critical for creating and developing S&T capabilities -a prerequisite for catching-up with countries at the technology frontier, or for supporting research projects with high expected social benefits (see Figure 3.8).

In the EU-25, government funding of R&D has been very stable since the end of the 1990s at around 0.64% of GDP (last year available: 2005). In the US, government-funded R&D shows more variability: it decreased from 0.8 to 0.7% of GDP between 1998 and 2001 and rose again from 0.71% of GDP in 2001 to 0.83% in 2004..

Figure 3.8: Public versus private funding of R&D (GERD funded by government and by industry, as % of GDP), 2005



Source: DG Research
Data: Eurostat, OECD
Notes: (1) IT (Italy): 1996; MT (Malta): 2002; BE (Belgium) DK (Denmark) EL (Greece) LU (Luxembourg) NL (Netherlands) PT (Portugal), SE (Sweden): 2003; BG (Bulgaria), DE (Germany), EE (Estonia), FR (France), CY (Cyprus), RO (Romania), FI (Finland), UK (United Kingdom), US (United States), JP (Japan): 2004 AT(Austria): 2006 (2) CN (China): Hong Kong is not included.

3.3.2 Performance

It was hoped that by better organising research in Europe, while stimulating greater investment in R&D, the Union could achieve higher levels of performance in science, technology and above all in innovation and competitiveness.

Of course it is difficult to trace a direct link between ERA-related measures and global improvements in the production and exploitation of research. For one thing, ERA policies are only part of the story, and many other factors contribute to shaping Europe's overall performance - for example, other policies (education, fiscal, trade, etc.), the global economic context, and so on. It is also important to bear in mind that societal and economic impacts resulting from the improved exploitation and commercialisation of research can take a number of years to emerge. In addition, the statistics that allow us to observe such improvements require some time to collect and collate, and are often two or three years old by the time they are available for analysis.

These considerations mean that trends need to be interpreted with caution. On the one hand, some of the effects of ERA policies may still be working their way through the innovation system. On the other hand, some observed improvements in EU performance may be due to factors other than ERA. Nevertheless, taking stock of available evidence is important, and if ERA policies are effective one would hope to see some first signs of improvement in Europe's main indicators of performance.

The quality of Europe's scientific publications

This section summarises some trends on the quality of Europe’s scientific output based on bibliometric evidence (‘quality’ being primarily measured here by the citation impact scores of scientific publications). The analyses are based on data extracted from the Science Citation Index (SCI) and related Citation Indexes on CD-Rom, produced by Thomson Scientific (formerly Institute for Scientific Information) and covering some 7,000 international journals in all domains of scholarship, with a good to excellent coverage especially in basic science.[168]

The EU-25 is the world's largest producer of scientific output, as measured by its share in the total world number of peer reviewed scientific articles (mainly published in English). In 2004, the Union represented 38% of the world's scientific output, against 33% for the US and 9% for Japan. China is ranking 4th worldwide, representing 6% of the world's scientific output.

However, the shares of both the EU and the US are declining since a few years, because of the rise of new global actors such as China and India. The total number of scientific publications produced each year grew by less than 10% in the advanced economies between 1997 and 2004 (by 6 to 7% in both the EU-25 and the US), while in the emerging countries it rose by more than 40%. Chinese annual scientific output almost doubled between 1997 and 2004, mirroring the rapid expansion and internationalisation of the Chinese S&T system.

Moreover, the leadership of the EU-25 in terms of total scientific output disappears when one adjusts for size and input: while the US and the EU-25 have similar levels of public R&D expenditure (in 2004, the EU-25 devoted 0.66% of its GDP to public R&D, against 0.69% for the US), the US produces significantly more scientific publications per million population (in 2004, 894 publications against 662 for the EU-25), or per university researcher.[169]

Finally, being s' world's largest producer of scientific output does not necessarily mean that the EU also ranks first as regards the impact of its scientific output. Mounting evidence shows that Europe's scientific impact lags significantly behind that of the US in (almost) all scientific disciplines. It tends also to demonstrate that in this regard there hasn't been any improvement compared to the US in the overwhelming majority of scientific fields since the mid-nineties.

Citation impact scores per scientific sub-field

One of the most widely used proxies to assess the impact of scientific work are citations. Citations to scientific articles provide an indication of the extent to which the scientific work of a research unit/university/country has influence and impact on the world scientific community. The more citations a scientific oeuvre gets, the bigger its impact and relevance.

In this section, the so-called 'Field-Normalised Citation Impact Score' per scientific discipline is used as impact indicator. This indicator is considered as one of the most suitable measures for international comparisons. It is the ratio of the actual number of citations received per publication (excluding self-citations) published in a scientific sub-field to the ‘expected’ (average) number of citations received by all papers published worldwide in the same sub-field.[170] If the ratio is above 1.0, this means that the scientific oeuvre is cited more frequently

[168] For more details on the SCI and its fields’ coverage, see MOED, H. F. (2005), 'Citation Analysis and Research Evaluation', (Information Science and Knowledge Management 9), Springer, Dordrecht, 2005, p. 119-136.

[169] 'Public R&D expenditure' is the total expenditure for R&D performed in both the 'Higher Education sector' and the 'Government sector' (HERD + GOVERD) (source: Eurostat, OECD).
Thomson Scientific, processed by CWTS / Leiden University.
DOSI, G., LLERENA, P. and LABINI, M.S., "The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox' ", *Research Policy* 35 (2006), p. 1454.

[170] The absolute number of citations is normalised by dividing by the average number of citations of the sub-field to correct for differences in publication and citation habits between fields: for instance, scientific fields

than the world average. The denominator (average number of citations per sub-field) is a weighted average taking into account differences in impact between the journals related to the sub-field in question (thus high-impact journals are more heavily weighed than low-impact journals).[171]

Figure 3.9 presents recent data on the 'Field-normalised Citation Impact Score' per scientific discipline for both the EU-25 and the US. It shows that the EU-25's scientific impact is around or below world average in almost all scientific disciplines. The EU-25 demonstrates a citation impact score above world average in 6 out of the 37 sub-fields, namely in 'Information and Communication Sciences', 'Physics', 'Astronomy', 'Civil Engineering', 'Earth Sciences' and 'Chemistry'.

Compared to the US, the EU-25 demonstrates lower impact scores in 35 out of the 37 scientific disciplines [in two sub-fields of the Social Sciences the EU-25 shows a higher ('Information and Communication Sciences') or similar ('Social Geography and Demography') score]. The gap with the US is particularly striking (i.e. difference in citation impact >0.5) in disciplines such as 'Chemistry', 'Computer Sciences', 'Material Sciences' (in terms of number of publications the most important sub-field of the 'Engineering Sciences'), 'Economics', and 'Statistical Probability and Analysis'.

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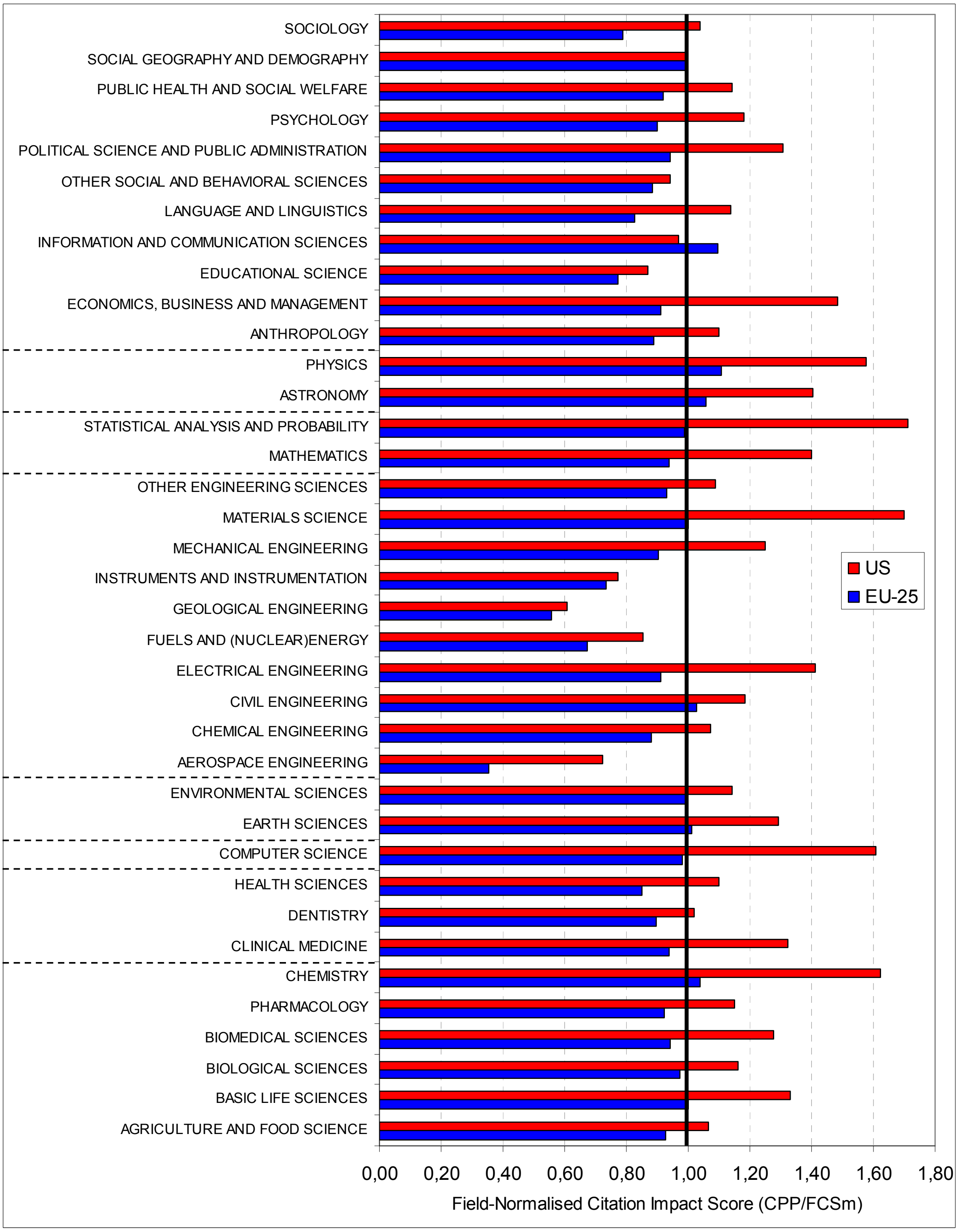
characterised by large publication output (e.g. physics) will tend to have less citations per publication on average than fields generating a low publication output (e.g. computer sciences).

[171] The citation impact indicator normalised per scientific sub-field has been preferred over an indicator normalised per journal. When normalising by journal, one does not take into account (differences in) the quality or impact of the journals in which a country publishes. In other words, the factor 'quality of the journal' is 'cancelled out' because it is the journal's mean average citation score that constitutes the benchmark, appearing in the ratio's denominator. As a result, a country publishing low impact publications in low impact journals may get a similar score as a country publishing high impact publications in high impact journals. The impact or quality of the journals in which a country publishes should not be cancelled out, but taken into account. This is the case in this section by using a field-normalisation which is obtained by calculating a weighted average of the citation rates of the Journals appearing in the scientific sub-field in question.

Figure 3.9: Field-normalised citation impact score per scientific discipline: the EU-25 versus the US, 2002-2004.



Source: DG Research
Data: Thomson Scientific, processed by CWTS / Leiden University
Note: This graph refers to scientific articles published in 2002 and citations occurred in 2002, 2003 and 2004.

In all the ‘largest publishing’ sub-fields (i.e. 'Basic Life Sciences', 'Biomedical Sciences', 'Chemistry', 'Clinical Medicine' and 'Physics'; together accounting for almost two-thirds of the total number of scientific articles published worldwide), the EU-25 scores significantly lower than the US.[172]

Between 1997 and 2004, this EU-US gap in citation impact scores remained unchanged in 26 out of the 37 scientific disciplines.[173] The gap increased even further in 7 disciplines: in ‘Computer Sciences’, ‘Electrical Engineering’, ‘Materials Science’, ‘Other Engineering Sciences’, ‘Mathematics’, ‘Statistical Analysis and Probability’ and ‘Economics’. Conversely, in 6 scientific disciplines (‘Basic Life Sciences’, ‘Chemical engineering’, ‘Civil Engineering’, ‘Educational Science’, 'Information and Communication Sciences' and ‘Political Science’), the EU-25 has been catching-up with the US as regards citation impact. As regards the 'Information and Communication Sciences, the EU-25 not only caught up with the US, but even took over the lead over the recent years.

The results presented above tend to show that the EU-25 still lags significantly behind the US in terms of impact of its scientific output. They also tend to demonstrate that in this regard there hasn't been any improvement compared to the US in the overwhelming majority of scientific disciplines since the mi-nineties. This result is consistent with other recent analyses.

The French *'Observatoire des Sciences et des Techniques'*, for instance, published recently 'Field normalised citation impact scores' for the EU-25 and the US. Even though the classification of scientific fields used by OST is not entirely comparable with the classification used above, the results (e.g. citation impact scores above world average for the EU-25 in 'Chemistry' and in 'Physics', but impact scores significantly below the US’s in all fields) are consistent with the findings mentioned above.[174] King (2004) computed a 'field-normalised citation impact score' at the country level (across all disciplines) for 16 EU Member States, the US, Japan and few other countries.[175] Even though the results are not fully comparable (i.e. period studied is longer: 1993-2002 and no EU-aggregate is presented), the overall conclusion is consistent with the findings presented above.[176] The 2005 EC report on 'Frontier Research' also examined citation impact scores per discipline and came to very similar conclusions.[177]

Using a citation impact indicator normalised by journal tends to show better results for the EU as compared to the US.[178] As already said, a normalisation by scientific sub-field (where

[172] Although the possibility of a 'US bias' in citation practices (US authors over-citing US papers as compared to other countries) is often presented as a potential cause of US superiority in citation impact scores, it is still a heavily debated question in scientometric literature and no consensus seems to emerge with regard to either the existence of such a bias or the extent of its impact (see for instance VAN RAAN, A.F.J., "Fatal Attraction: Conceptual and methodological problems in the ranking of universities by bibliometric methods", *Scientometrics*, Vol. 62, nr. 1 (2005), 133-143 (especially p. 138-139)).

[173] I.e. the difference in citation impact score between the EU-25 and the US varied by less than 0.1 between 1997 and 2002.

[174] OST, Key Figures on Science and Technology 2006, Paris, p.47.

[175] KING, D. A., 'The scientific impact of nations. What different countries get for their research spending', *Nature* (vol. 430), July 2004, 311-316.

[176] According to King's calculations, the citation impact scores increased in almost all countries. It increased faster than in the US in 8 out of the 16 EU Member States (in Denmark, the UK, Germany, Austria, Ireland, Luxembourg, Spain and Poland) and slower than in the US in the other 8 EU Member States (in the Netherlands, Belgium, Sweden, France, Italy, Finland, Portugal and Greece). Both groups of countries represent about half of EU-16's scientific output. One cannot thus derive from these figures any improvement of the EU’s position relative to the US (KING (2004), 311-312).

[177] '[…] the US, although producing a broadly similar number of scientific publications to Europe, leads both in terms of total number of citations (reflecting the total impact of research) and in terms of the average number of citations per paper (reflecting the average impact per paper)' (European Commission (2005) p. 26).

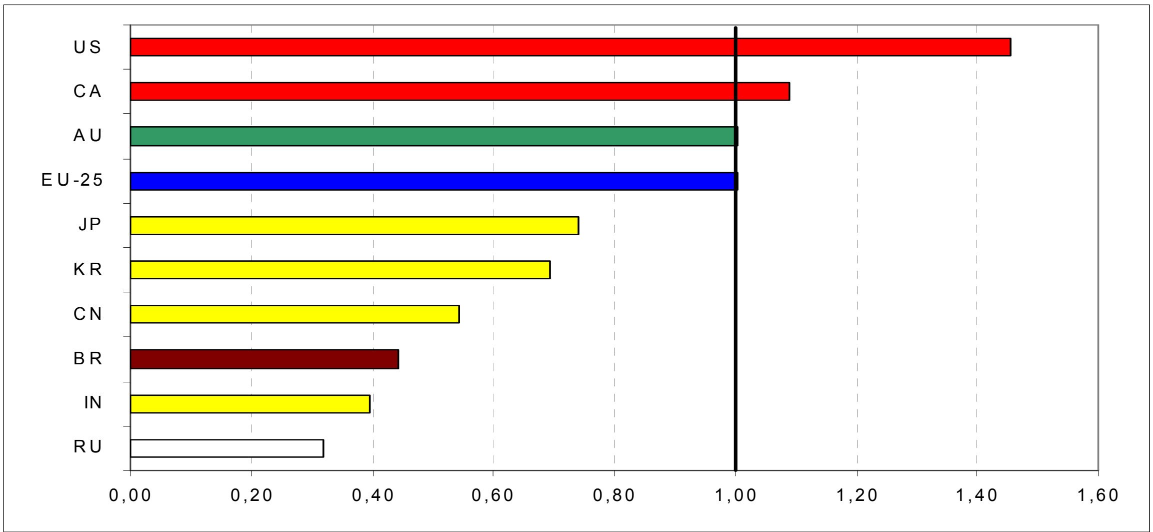
[178] For instance the 2002 report of the Expert Group on ‘Benchmarking S&T Productivity’ provided an assessment of the citation impact performance of EU-Member States as compared to the US (see European Commission (2002), ‘Final report of the Expert group on *Benchmarking S&T Productivity*’, June 2002, p. 16-19). For various Member States the report demonstrates an improvement of the citation impact against the US between the late

differences in impact between journals have been taken into account) has been preferred here above the normalisation by journal. However, it is interesting to consider this difference between the two types of indicators, since it demonstrates that US scientists on average publish more frequently in high-impact journals than EU scientists.

The contribution to high-impact, highly-cited publications

An additional impact indicator reflects the contribution of a region to the most frequently cited papers worldwide. Two regions A and B may have equal citation impact scores at a field level while showing different contributions to the highly-cited, high-impact publications because of different distributions of citation rates.[179] The indicator used here measures the contribution of a region to (the top 10%) highly-cited publications. It enables one to assess whether the number of frequently cited papers produced by a given country is higher or lower than expected on the basis of the region's total publication output.

Figure 3.10: Contribution to the 10% most cited scientific publications, 2001-2004



Source: DG Research
Data: Thomson Scientific, processed by CWTS / Leiden University
Note: This graph refers to the 10% most cited scientific articles published in 2001 and cited during the 2001-2004 period. Luxembourg, Malta and Cyprus were not included in the EU-25 average because of too low numbers.

Even though the EU-25 shows a contribution to the (top 10%) high-impact publications that corresponds more or less to what can be expected given its publication output (i.e. around 1.0), it lags significantly behind the US in this regard. The US has, compared to the EU, a disproportionate number of highly-cited publications. Looking at the - even more outstanding - top 1% most cited publications confirms this result.[180]

eighties and 1996. Some Member States such as Germany and the UK even show higher citation impact scores than the US.

[179] For instance, region A publishes a steady stream of relatively well cited papers while failing to produce really high impact publications, whereas region B generates a considerable number of high impact publications while at the same time producing large numbers of less well cited publications.

[180] 'Analysis of the top 1% of publications in terms of citations reveals even more discouraging evidence for Europe [than when looking at citation impacts scores]. In almost all fields, the US dominates in terms of high-impact papers. Its share of highly-cited publications is disproportionately much larger than its share of total publications' (European Commission (2005) p. 26).

Citation impact score of world's largest research universities

The following paragraphs analyse the citation impacts scores of the world's largest research universities (in terms of publication output). It presents general patterns for a set of the 386 most frequently publishing world universities (i.e. having published at least 5,000 articles between 1997 and 2004). This set contains 172 EU-25 universities and 122 US universities, representing respectively 72% (EU-25) and 83% (US) of all university scientific articles.[181]

US universities are highly overrepresented in the top of the ranking based on normalised citation impact, and to a lesser extent, on the number of published articles per year. In the group of the 25 universities with the highest citation impact, all universities are from the US and in the group of 76 universities with a citation impact above 1.5, 67 (88%) are located in the US.

Differences between EU and US universities can also be analysed via an institution's citation impact *per discipline*, using a categorization of research into 15 broad disciplines. Only 26% of the EU universities are world leaders (i.e. being among the top 10% with regard to citation impact) in at least one discipline, against 81% of the US universities. Regarding the 'very best' universities in a region, although proportionately more EU universities are part of the world top, a significant difference remains compared to their US counterparts. Moreover, the number of disciplines in which an EU university is world leader is on average substantially lower than that calculated for US universities. In other words, many EU universities belong to the world 'top', but their top is less broad (in terms of discipline coverage) than that of their US counterparts.

Performance in invention and innovation

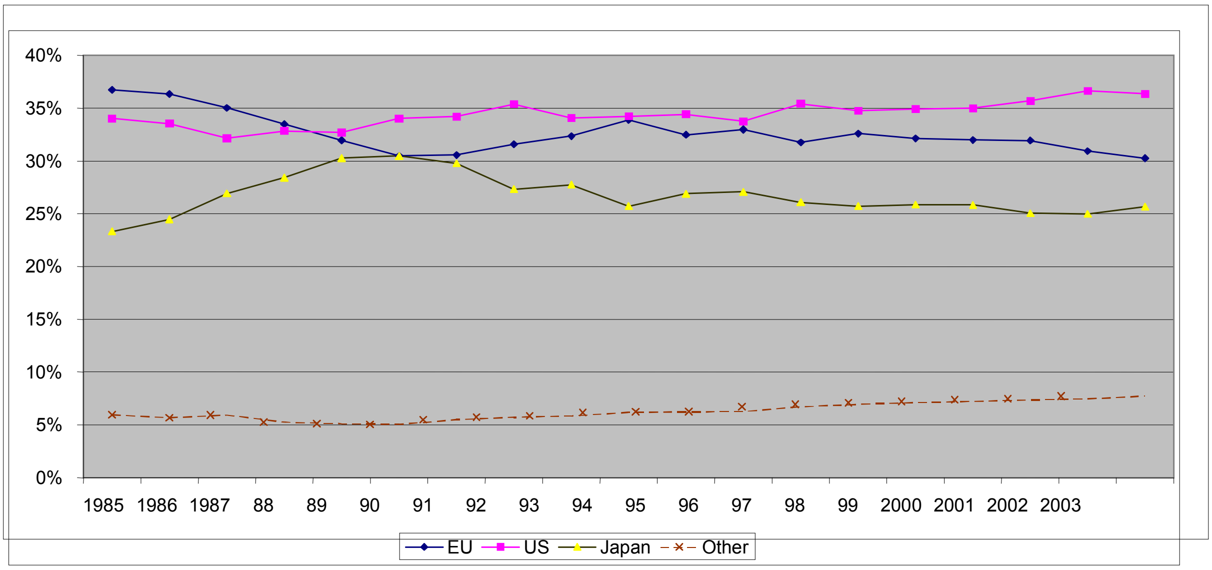
A key weakness highlighted in the ERA Communication of 2000 concerns Europe's ability to exploit scientific knowledge through the generation of new technological knowledge and innovation. However, there are signs that Europe's performance in this regard remains problematic. Its share of triadic patents (see Figure 3.11) is below that of the US (30% compared with 36% in the US).[182] If one looks at set of patents associated with high tech areas (see Figure 3.12) Europe's share has fallen from 33% to 29% since 2001.[183]

Figure 3.11: World share of triadic patents

[181] H. F. MOED (2006), 'Bibliometric Rankings of World Universities', (Centre for Science and Technology Studies (CWTS), Leiden University) (CWTS Report 2006-01), Leiden, August 2006.

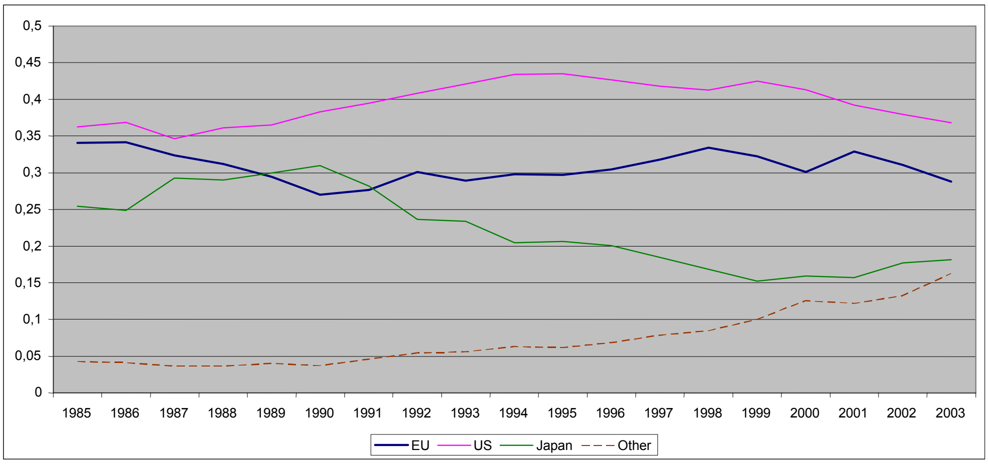
[182] "Triadic patents" refer to the set of patents filed at the EPO, the JPO and USPTO to protect the same invention. Because they represent patents filed in the three major patent offices, patent families are often considered to be high-quality patents that inventors expect to exploit globally and for which they are willing to pay application and maintenance fees to multiple patent offices.

[183] The data relate to patents applied for at the European Patent Office.



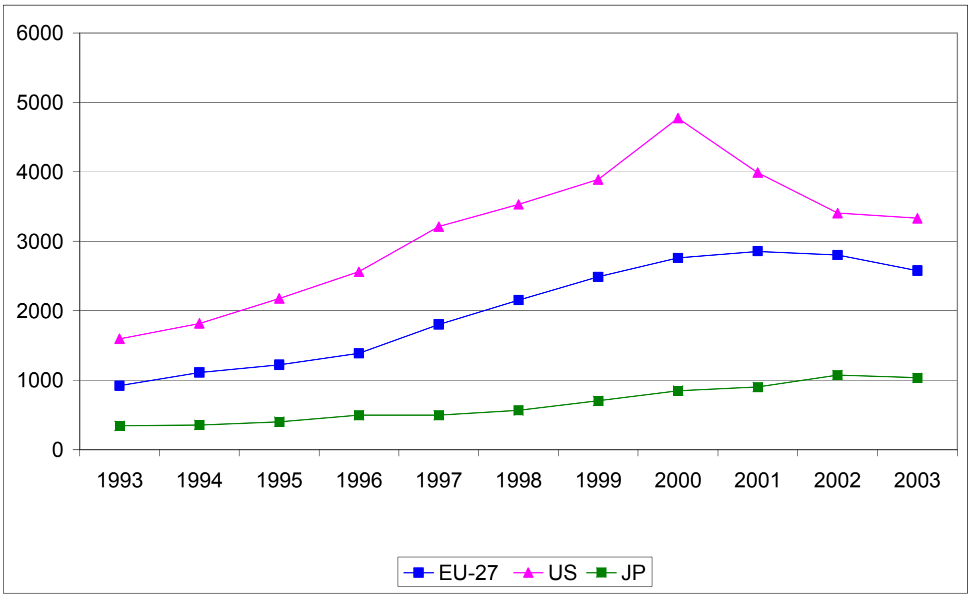
Source: DG Research; Data: OECD

Figure 3.12: World shares of high tech patents (EPO applications)



Source: DG Research
Data: Eurostat

Figure 3.13: Biotechnology patent applications (EPO applications)



Source: DG Research
Data: Eurostat

While the EU still has fewer patent applications in the field of biotechnology than the US (Figure 3.13), the gap has decreased since 2000. In the domain of ICT, the EU and the US are very close, with the EU-27 applying for 16010 patents at the EPO in 2003, compared with 16823 applications from the US.[184]

Recent years have also seen new countries emerging with strong growth in patenting activity, notably from Asia. India and China, in particular, have seen very rapid growth in patents – albeit from a low base: India's applications to the European Patent Office grew by an annual average of 46% between 1998 and 2003, while China registered a 40% growth over the same period.[185]
A somewhat broader view of innovation performance can be obtained from the European Innovation Scoreboard, which is calculated using a range of S&T and innovation indicators.[186] These cover data on R&D spending and S&E graduates, but also include measures relating to patenting, trademarks and designs, ICT investment, and employment in high tech sectors. The latest data for 2006 show that there is still an important gap to close between the EU-25 and the US and Japan, although there are signs of some improvement since 2002 (see Figure 3.14). Key components of this gap relate to business R&D, early stage venture capital, percentage of the population with tertiary education and patenting at the US Patent Office. The Innovation Scoreboard also indicates the differences between EU Member States in terms of innovation efficiency (the relationship between input and output).

Figure 3.14: EU-25 innovation gap towards the US and Japan (JP)

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[184] Eurostat, *Statistics in Focus – Science and Technology* 20/2007.
[185] Eurostat, *Statistics in Focus – Science and Technology* 9/2007.
[186] For more details see http://www.proinno-europe.eu/doc/EIS2006_final.pdf. The component indicators are: S&E graduates per 1000 population aged 20-29, Population with tertiary education per 100 population aged 25-64, Broadband penetration rate (number of broadband lines per 100 population), Public R&D expenditures (% of GDP), Business R&D expenditures % of GDP), Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures), Early-stage venture capital (% of GDP), ICT expenditures (% of GDP), Exports of high technology products as a share of total exports, Employment in medium-high and high-tech manufacturing (% of total workforce), EPO patents per million population, USPTO patents per million population, Triadic patent families per million population, New Community trademarks per million population, New community designs per million population.

Source: DG Enterprise, 'European Innovation Scoreboard 2006'.

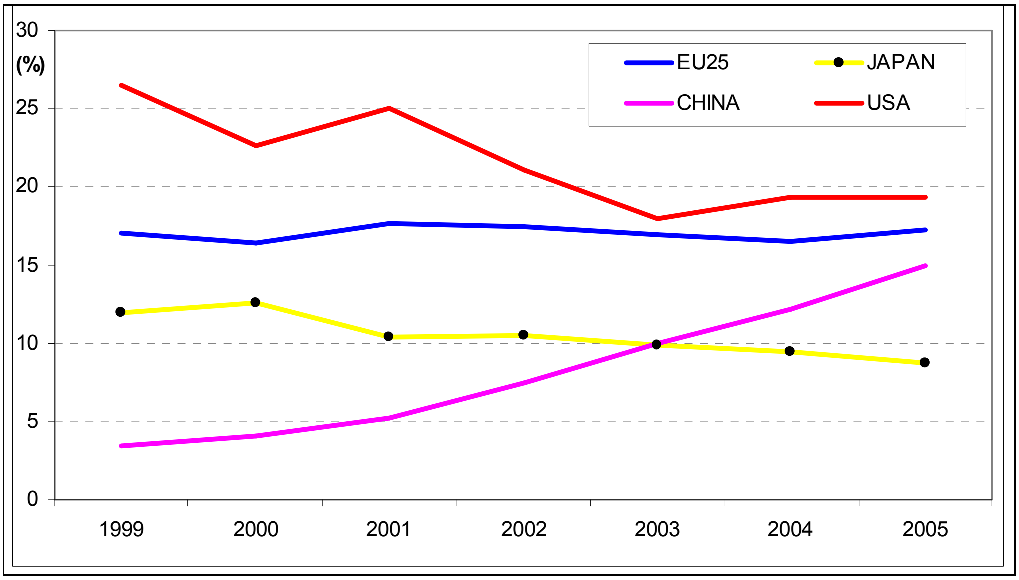
Trade in high technology products

When it comes to commercialising the results of research and new technological knowledge through sales of high tech products on international markets, there are few indications of a dramatic improvement in Europe's position.

Europe continues to have a lower share of the world market in high tech exports than the US (17% versus 19% in 2005 – see Figure 3.15). While the gap has narrowed since 2001, this is due primarily to the US losing market, with the EU share remaining more or less stable.

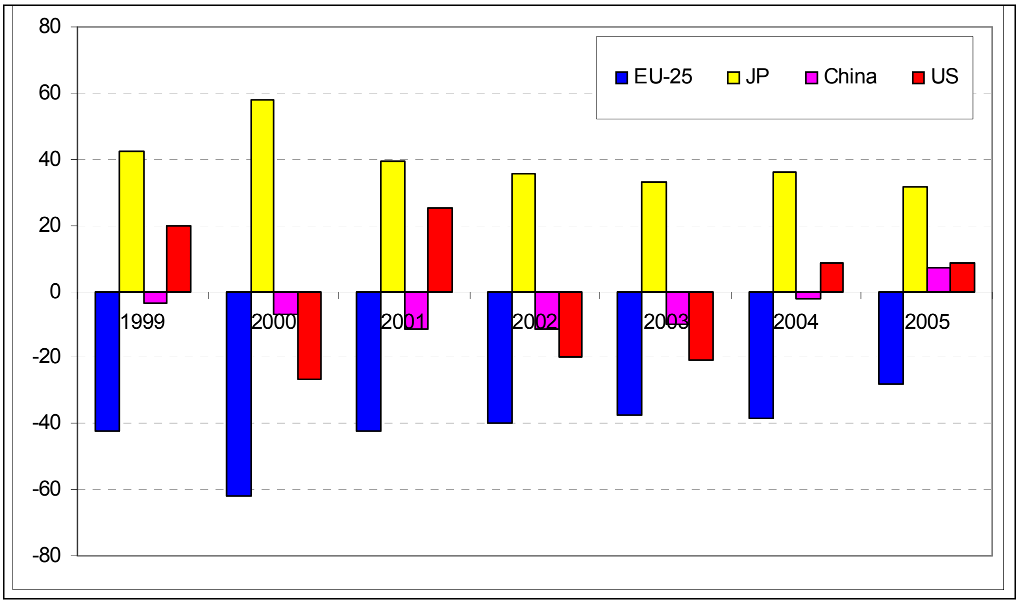
At the same time, Europe has a lower percentage of high tech products in its exports - 18% against 27% for the US and 22% for Japan – while its trade deficit has fallen somewhat since 2001, reaching €28 billion in 2005 (see Figure 3.16).

Figure 3.15: Export of high-tech products: World market share 1999-2005



Source: DG Research, JRC
Data: Eurostat (Comext), UN (Comtrade)

Figure 3.16: High-tech trade balance (€ billions), 1999-2005

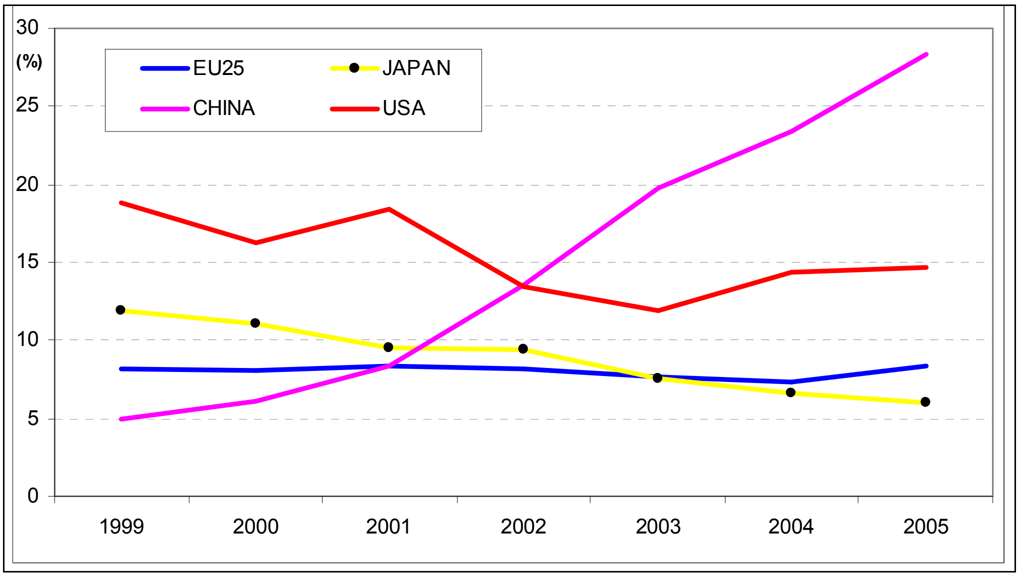


Source: DG Research, JRC
Data: Eurostat (Comext), UN (Comtrade)

Europe's position in international markets varies significantly according to the high tech product area. For example, it still has a lower market share than the US when it comes to exports of computers and of electronics and telecommunications (see Figures 3.17 and 3.18). However, it is well ahead of the US and Japan in pharmaceuticals (see Figure 3.19).

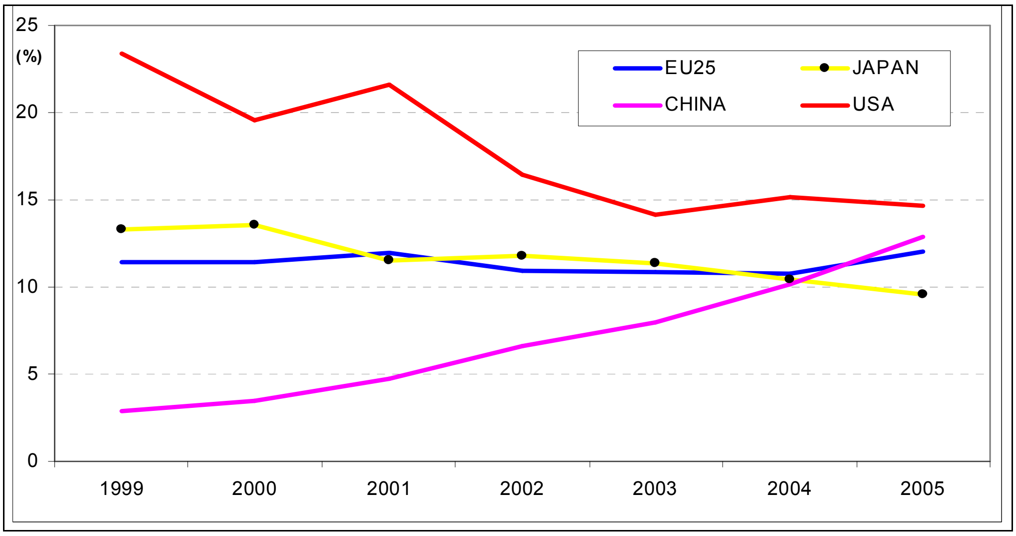
What has been most striking in these developments, however, is China's emergence as a key exporter of high tech products. Its market share of all high tech exports has risen dramatically from 3% in 1999 to 15% in 2005 (just below that of the EU, and above Japan). This has been driven in large part by a massive surge in exports of computers – where its market share is now higher (28%) than the US and Japan - and in electronics and telecoms where it is now ahead of Japan with a 13% share of global exports. Unlike the US and Japan, Europe has not yet seen a serious decline in its share of these international product markets, but nor is it the leading player in these areas. The EU's relatively stable high tech market share may be due to the fact that Chinese growth has not yet eaten into the markets where Europe is strong (such as pharmaceuticals).

Figure 3.17: Export of high-tech products 1999-2005: Computers and office machinery



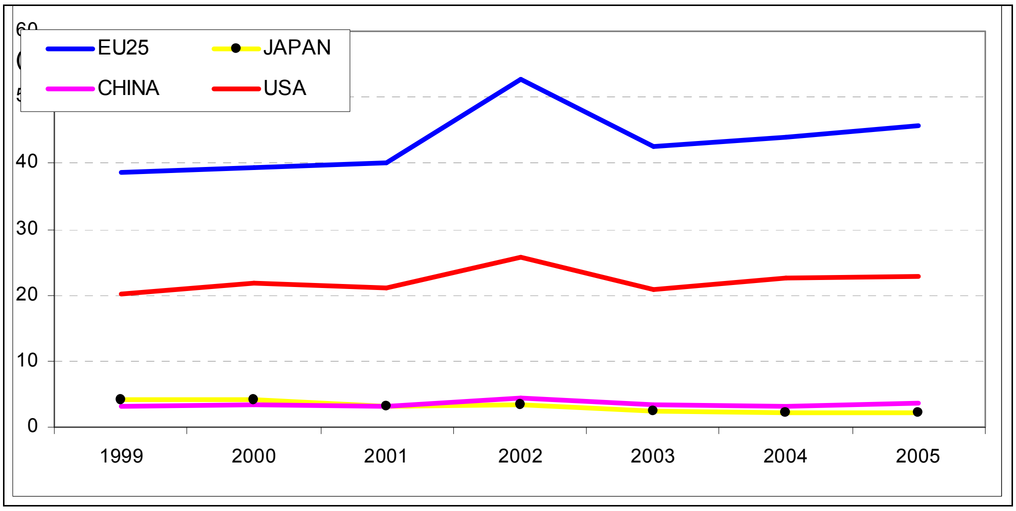
Source: DG Research, JRC
Data: Eurostat (Comext), UN (Comtrade)

Figure 3.18: Export of high-tech products 1999-2005: Electronics and telecom



Source: DG Research, JRC
Data: Eurostat (Comext), UN (Comtrade)

Figure 3.19: Export of High-tech products 1999-2005: pharmaceuticals



Source: DG Research, JRC
Data: Eurostat (Comext), UN (Comtrade)

3.3.3 ERA and the implications for evidence-based monitoring and evaluation

The European Research Area centres around the idea of developing a more coherent overall policy framework conducive for European research through mobilising critical mass, reducing costly overlaps and duplications and making more use of coordination and integration mechanisms involving all levels of policy intervention in the European Union.

The successful implementation of the European Research Area is, therefore, closely linked to the availability of accurate analyses at ERA level on the impact and effectiveness of research activities and policies, including those of the Members States and the EU, and through this the development of evidence-based policy.

The implications for evaluation and monitoring are multifold. A new breed of impact studies will be necessary to analyse the interplay between national, regional and European RTD initiatives.[187] Effects of national initiatives on the European research system will have to be analysed in parallel with assessing the impact of European programmes on national and regional research systems. Establishing the 'European added value' of a particular intervention will become part of each evaluation. In addition to the right policy level, assessing the right mix of policy instruments will be crucial and will need the input from a variety of evaluation methodologies as well as other inputs such as benchmarking studies, foresight activities, indicator work, impact assessments, etc.

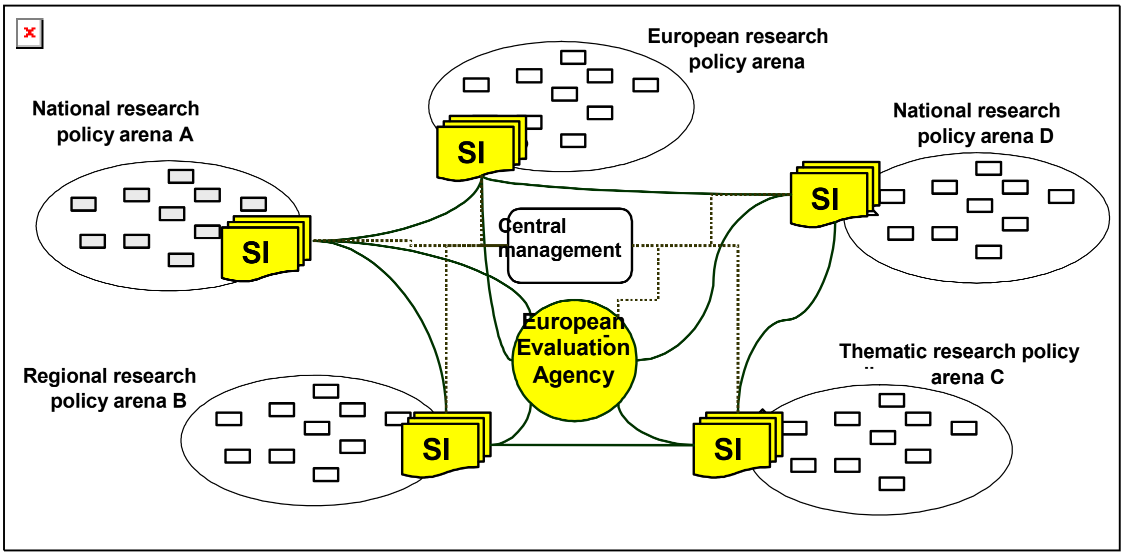
The connection between ERA and evaluation and monitoring was recognised from the start and was highlighted in a major evaluation report in 2002 which called for the creation of a European Research Evaluation Area in parallel with establishing ERA.[188]

The current evaluation and monitoring system is not optimally equipped for this challenge. The main reason for this is because each level of policy intervention performs the evaluation function separately of other intervention levels which makes it difficult to assess the impacts of a particular policy measure in a wider framework; to learn from similar policy measures in other regions and countries in the European Union given the differences in institutional settings; and to improve the policy design and delivery mechanism when the impact of policy support undertaken at other policy levels is unknown.

[187] L. Georgiou & S. Kuhlmann, 'Chapter 6 - Future Policy Instruments: Evaluation of the Socio-Economic Effects in the European Research Area', In: IPTS et al., RTD Evaluation Toolbox, 2002, pp. 203-210.
[188] 'Assessing the Socio-economic implications of the Framework Programme (ASIF)', 2002.

Put differently, the potential of strategic intelligence present in the overall system remains underexploited. This means that policy-makers only have access to a small share of the policy-relevant information they need and the methodological tools they could use to assist policy design and policy evaluation.[189] In addition, resources earmarked for evaluation at all policy levels are modest and unlikely to increase substantially in the near future.

Figure 3.20: Architecture of distributed strategic intelligence in European Research Area



Source: DG Research adapted from IPTS et al., 2002, RTD Evaluation Toolbox

Rectifying this situation will require the development of interfaces to enhance the visibility and accessibility of existing information. It means raising awareness among potential users to adopt a broader perspective in their search for strategic information; activating the nodes at different levels of the system to allow for links amongst and across the existing regional, national, sectoral and transnational infrastructures, and organising a central management function that is there to help the users by facilitating the search function, by giving methodological advice, by performing evaluations at system level, by providing quality assurance, by setting common evaluation standards, by organising a central evaluation 'observatory', etc.[190] How this should be done is part of the discussion on how to organise an evaluation and monitoring system better equipped for ERA.

At present, there is a strong base from which to develop ERA level evaluation and monitoring. The scale of research evaluation work in the EU appears to be increasing as is its sophistication and coverage which means there is a now a great deal of evaluation evidence to make use of.[191] Increasing attention is given to networking between evaluation experts and officials involved in evaluation, such as through the European RTD evaluation Network which is organised by the European Commission around the concept of the European Research Area.[192] Networking and

[189] L. Georgiou & S. Kuhlmann, In: IPTS et al., RTD Evaluation Toolbox, 2002, pp. 203-210.
[190] L. Georgiou & S. Kuhlmann, In: IPTS et al., RTD Evaluation Toolbox, 2002, pp. 203-210.
[191] The Court of Auditors report from 2006, Observations on the Evaluation Framework of the Commission reported that both DG RTD and DG INFSO were in the top category in terms of the organisation of their evaluation function, the level of human resources available, procedures for assuring quality and experience of carrying out evaluations.
[192] Part of the rolling programme of Network activities, with meetings being held under each EU Presidency, are three working groups which work on evaluation standards, sharing evaluation data, and the identification of shared evaluation research needs.

information exchange have also been supported through an increasing number of international evaluation conferences hosted in Europe over recent years, several of which organised by the European Commission. The European research evaluation community is relatively strong and is held in high regard. A number of Member States are already carrying out ad hoc national impact evaluations on the effects of Framework Programme funding in their countries. Also, evaluation functions have been strengthened in several Member States, notably through the creation of dedicated evaluation agencies or specific evaluation units. In addition, the exchange of ideas with other leading edge countries in this domain, like US, Canada or Australia, has become more intense.

This base allows for and invites to further develop a more comprehensive approach to evaluation and monitoring in support of ERA, or indeed a European Research Evaluation Area. The specific characteristics would include the following features:

- Sharing the results of evaluation studies and other programme evaluation data;
- Joint development and implementation of common evaluation studies;
- Common standards and good practice for evaluation;
- Sharing of evaluation experts and the promotion of a common pool of highly qualified evaluation expertise;
- Other joint initiatives for the development of tools and approaches, including indicators.

3.3.4 Highlights

- ✓ Not much progress has been made towards the EU R&D investment target of 3% of GDP (two thirds of which to come from private sources) since this objective was set in 2002.
- ✓ The deficit in R&D intensity of the EU versus the US has not been reduced - on the contrary - and China will have probably caught up with the EU-27 by 2009 in terms of its share of GDP devoted to R&D.
- ✓ Comparing absolute amounts of R&D spending between regions of similar sizes shows that the absolute R&D expenditure gap between the EU-25 and the US has not been reduced, while a similar gap is emerging with a several dynamic Asian economies (China, Japan, South-Korea, Taiwan and Singapore).
- ✓ Substantial amounts of R&D spending are flowing out of Europe. As a result, the EU's share in world R&D expenditure is under pressure.
- ✓ While the EU is nominally the world's largest producer of peer reviewed scientific articles, this is not the case when one adjusts for size and input. Moreover, recent evidence on citation impact and highly-cited publications shows that Europe's scientific impact still lags significantly behind that of the US in 35 out of 37 scientific sub-fields, and that it has not been improving in this regard since the mid nineties.
- ✓ Europe's performance in terms of patenting and high technology trade is fairly stable, but an overall assessment of innovative performance indicates that there is still a gap between Europe and the US and Japan, although there are signs that it is closing.
- ✓ S&T performance is not the same as innovation performance and S&T statistics are more narrowly defined than innovation statistics. The 2006 Innovation Scoreboard makes use of some S&T statistics (public R&D expenditure as a share of GDP; business R&D expenditure as a share of GDP; share of medium-high-tech and high-tech R&D as a share of manufacturing R&D expenditure; exports of high technology products as a share of total

exports; EPO patents per million population; USPTO patents per million population; triadic patent families per million population) but does not use data on, for instance, researchers (and data on S&E graduates constitute a poor proxy since many S&E graduates in Europe flow into non-research jobs) and scientific publications (below table). It also makes use of a wide range of non-research related indicators. This explains why the picture presented by the 2006 Innovation Scoreboard may be more positive than that based on R&D statistics.

- ✓ A more comprehensive and indicator-based, where appropriate, approach to evaluation and monitoring in support of ERA should be developed across all policy levels.

ANNEX: Stocktaking of ERA actions at EU level in regard to the objectives defined in the ERA Communication of 2000

	Objectives defined in 2000	Actions undertaken and results obtained/expected	Barriers and difficulties encountered
1. A SERIES OF MATERIAL RESOURCES AND FACILITIES OPTIMISED AT EUROPEAN LEVEL			
1.1. Networking of centres of excellence and creation of virtual centres	To reduce the fragmentation of European research by combining complementary expertise to attain a critical mass of financial and human resources.	• The sixth Framework Programme (FP6) introduced Networks of Excellence (NoE) [aimed at establishing durable, virtual centres of excellence in specific research areas by grouping expertise and research capacities around a joint programme of activities] and Integrated Projects (IP) [aimed at large-scale, strategic, objective-driven co-operative research requiring the integration of a critical mass of activities and resources] to address this objective. • 532 IP and 152 NoE were launched under FP6 by July 2006. For NoEs, the EC contribution represents about 56% of the total costs of all NoE. For IPs the figure is 60%. For all other instruments the figure is 67% implying a greater leverage on national and private funds by new instruments compared with traditional ones. The HERMES IP for example receives € 15M EC contribution to total estimated project costs of € 60M. This may imply that IP and NoE have a greater effect on Member State (MS) research priorities than traditional project types. • Networking of centres of excellence and creation of virtual centres is also dealt with in section 1.3.	• The purposes of NoE and of IP were not fully understood by all stakeholders, in particular with respect to the concept of 'integration', as opposed to co-operation. This led to some NoE resembling IP and to some NoE being established where IP would have been more appropriate. Consortium size posed problems for management of both IP and NoE. • For NoEs: o The participation of industry, particularly SMEs, is unacceptably low. o Integration and durability were either misunderstood or ignored by representatives of NoE Governing Councils (participants' management) with the result that long-term binding commitments to support the Networks are rare. This risks re-fragmentation when EC funding ends. • For IPs o Large consortia created not only management difficulties but also IPR difficulties.
1.2. Definition of a European	To develop a European approach to infrastructures covering both the	• A series of 3 conferences organised by EC, the European Science Foundation (ESF) and the French Ministry of Research from 2000 to	• Infrastructures often require significant funds over a long period which cannot be

approach to research facilities	creation of new installations and the functioning of / access to existing ones. Concerning the creation of new installations, a specific objective was to make an accurate assessment of future needs to be addressed at European level.	2005 illustrated the wide consensus for a co-ordinated approach on European infrastructures. • The FP6 Integrated Infrastructures Initiatives combine networking activities, provision of access to infrastructures to trans-national users and joint research activities. Thus far, 248 facilities covering most research fields in Europe have been linked, representing 40% of all existing European facilities. • The European Strategy Forum for Research Infrastructures (ESFRI) involves Member States (MS), Associated Countries (AC) and EC and has published the First Strategic Research Infrastructures Roadmap for Europe in 2006. It proposes 35 projects for the construction or upgrading of pan-European Research Infrastructures. FP7 supports the creation of these infrastructures. • Existing European research infrastructures were surveyed in 2006 by the EC, ESF and Eurohorcs in order to establish a database. The results of this survey will shortly be presented to ESFRI.	provided by FP. Available FP7 funds compared with the original EC proposal limit the extent to which the ESFRI roadmap can be implemented. • The inflexibility of FP contracts can reduce the effectiveness of the infrastructure in responding to new developments. • Industrial reluctance to commit funds compounds this problem. • Not only do MS (and non-MS for international projects) vary in the level of commitment to infrastructure projects, their internal governance processes retard development even when there is agreement to proceed. • There is competition and inconsistencies between Community actions and intergovernmental ones (see section 2.2).
1.3. Maximising the potential offered by electronic networks	• To encourage the use of electronic networks in the various fields of research in European as well as national research programmes, in view of increasing the productivity of European research while helping to structure collaboration on a continental scale. • To encourage researcher awareness-building and training campaigns at national and European levels on the possibilities created by information technologies and communications.	The topic *Communication Network Development*, in the Programme *Structuring the ERA* launched actions in e-Infrastructures: • GÉANT2, a pan-European communication infrastructure for the research and education community, launched in September 2004, is the first network in the world to run at 10 Gb/s. • EGEEII - Enabling Grids for E-SciencE is the world's largest production Grid infrastructure addressing 10 different areas of science, linking 50 research organisations, having started its second two-year phase in 2006. • DEISA (launched in 2005) is a grid of 11 of the most important national supercomputers and is linked to the USA supercomputing infrastructure (TeraGrid) • Complementary initiatives designed to encourage researcher awareness were also launched.	• Limited budget hindered greater deployment of Grid infrastructures to many more scientific communities. • The uptake of advanced communication and collaboration techniques (e.g. Grids, scientific data repositories) to enable new ways of conducting science is still far too limited.

2. MORE CONSISTENT USE OF PUBLIC INSTRUMENTS AND RESOURCES			

2.1. More co-ordinated implementation of national and European research programmes	• The main policy objective defined in 2000 was the *reciprocal opening of national programmes* to potential participants from other Member States.
	• Related more specific objectives included information exchange and the establishment of an information system on existing national programmes as well as the evaluation of national research activities by international panels.
		• The ERA-NETs of FP6 aim to co-ordinate implementation of research programmes. Programme owners and managers across MS are brought together to reduce fragmentation in the funding of research activities across Europe.
		• A key element of ERA-NET is its bottom-up, variable geometry (in terms of participating countries) approach.
		• More than 1000 national and regional research programme owners participate to date in 71 ERA-NETs. Some 30 Joint Calls were launched by 2006. Early indications suggest that trans-national proposals submitted in response to joint calls have led to increased commitments by MS: by the end of 2006, MS had already committed together some M€ 250 in joint calls. The number of joint calls will double in 2007 and should reach in total some M€ 500 by end of 2007.
		• The FP7 ERA-NET "Plus" tool will allow EC to contribute to the funds available in trans-national calls initiated by MS.
		• FP6 also saw the Implementation of the first pilot action under 'Article 169' of the Treaty: the European Developing countries Clinical Trials Partnership ('EDCTP').
		• These initiatives have helped MS recognise the potential of interacting with other MS in funding research. More attention is now given to improving mutual compatibility regarding structural (governance level), administrative (e.g. eligibility, contracting, overheads levels) and timing (duration of programme cycles) aspects. In particular, new Member States are considering re-structuring their research efforts into programmes in order to increase compatibility.
		• Other initiatives with a structuring and/or co-ordinating effect at a strategic level include
		    • the National IST RTD Directors forum which is the main mechanism to develop and discuss common visions and strategies for ICT R&D in Europe, to share knowledge and best practice and to improve coordination in ICT RTD in Europe
			• ERA-NET is only a first step. MS remain reluctant to restructure their research programmes to allow joint programming. Subsidiarity is insufficiently observed. FP funds research which could be handled at national level.
			• In some areas (e.g. genomics), different ERA-NETs were set up on rather focused national programmes (e.g. on plant genomics, or pathogenomics). Better, strategic co-ordination is required to avoid 'fragmentation by ERA-Net'.
			• Progress in the first Art.169 Initiative (EDCTP) was hampered by MS's unwillingness to fully integrate programmes and to commit finances in the long term. Legal and administrative rules also caused difficulty. The new generation of Art. 169 initiatives under preparation aim to overcome these weaknesses.
			• There are also bottlenecks at the governance level :
			    • Lack of human resources and/of suitable structure by programmes, particularly in particular Southern and new Member States, make joint programming difficult.
			    • Different funding rules/ administration cultures make joint calls difficult.
			• National authorities are reluctant to open research programmes even when to do so would improve the science funded.

		• The Standing Committee on Agricultural Research (SCAR) which brings together representatives of Member States funding agencies to co-ordinate research in this area. • European Technology Platforms (ETP) which group stakeholders together in industry-led initiatives to define Strategic Research Agendas (SRA) for technological fields. ETPs have in turn given rise in some cases to the establishment of 'national' technology platforms which bring together national stakeholders and develop SRAs in line with the aims of the overarching ETP. • Examples of reciprocal opening of research programmes initiated by MS include the CNRS funding positions accessible to all EU researchers and the Nordic countries' Northern European Innovative Energy Research Programme (M€ 6 budget for projects). • Regarding an information system on EU research programmes, a pilot ERA-WATCH system has been launched and is being developed further. It is a web-based "research inventory" of national and regional structures, actors, policies, relevant legislation, programmes, budgets, priorities, human resources and support mechanisms in Member and Associated States. Comparative information will also be provided on major research partners such as the USA, Japan and China. The inventory will be regularly updated and will be used to produce regular analyses and reporting on general science policy issues relevant to research policy- making. • EC has also mapped research activities (outside ERA-WATCH) in specific domains: in the field of ICT, CISTRANA (htpp://www.cistrana.org) aims to develop a map of the national research landscape in the area of ICT and establish a portal with comparable information on national ICT R&D policies and programmes across Europe. Inventories of research activities have been constructed in other research domains (Nanotechnologies, materials science and production technologies; Transmissible spongiform encephalopathies. This is also planned for the Animal Health domain under the activities of SCAR).	• A single information system covering all the opportunities offered to researchers in Europe is lacking. • Funding opportunities and programmes are not well known outside MS borders; this can also be the case within an MS when multiple funding bodies are involved.
2.2. Closer relations	To provide the intergovernmental	• The EIRO forum is composed of CERN, ESA, EMBL, ESO, ESRF,	• The various types of European level

between European organisations for science and technology cooperation	organisations for European scientific and technological co-operation (ESF, ESA, EMBO, EMBL, CERN, ESO, ESRF, ILL, EUREKA, COST) with a framework in which they could discuss their respective roles on the European scientific and technological scene and their relations between one another and with the Union.	ILL, EFD and was formed in 2002, aiming to pursue joint initiatives, combine resources and share best practices.
		• EuroHORCs (European Heads of Research Councils) and ESF: Cooperation on specific issues has developed, including through joint EuroHORCs and ESF–Commission working groups.
		• Efforts are underway to establish co-operations with other groups of research organisations such as TAFTIE, EARTO and Research Performing Organisations.
		• COST: A partnership was established between COST and the Commission to reinforce coordination between the FP and COST and to seek complementarities and synergies between the two frameworks.
		• EUREKA: Collaboration between EU activities and EUREKA progressed and has taken concrete forms:
		  • A Commission-Eureka Inter Service Group was set up to spread information about Eureka across Commission services and discusses issues of cooperation.
		  • Joint Technology Groups between EUREKA Clusters (Mega-projects in Eureka) and Umbrellas (thematic networks to generate smaller Eureka projects) and Thematic priority directorates in the Commission were set up. A number of these JTG's contributed to the development of ETPs
		  • Cooperation between the FP and EUREKA is being strengthened, notably through the preparation of the following two actions:
		    1) The "Eurostars programme" initiative, under Art. 169 of the Treaty, aimed at highly innovative SMEs
		    2) The involvement of EUREKA Clusters in the preparation of two candidate Joint Technology Initiatives: Artemis (embedded computing systems) and Eniac (nanoelectronics).
			Research Organisations and initiatives are different in nature and tend to operate in different ways. Networking is therefore not simply achieved. Diversity of mission, of legal status, of the governance and budget structure, national legislation and the variable geometry of membership (the membership of EIROforum organisations - in terms of countries- varies from one to another) all set limits to the degree of coordination with and between these organisations.
			• EUREKA has shown repeatedly a weakness of synchronisation of funding and of insufficient funding in many of its Member Countries. Although this is not directly an EU matter, it has bearings on the coordination between the FP and EUREKA.
			• The long and complex discussion around the setting up of the Eurostars programme shows the difficulty of many countries to transfer control to a central structure over the final decision on how to allocate their financial contributions.

		• Whilst not an explicit objective of the 2000 Communication, the establishment of a public procurement expert group represents a direct means to support R&D and as such falls under the	

		heading "more consistent use of public instruments and resources"	
3. MORE DYNAMIC PRIVATE INVESTMENT			
3.1. Better use of instruments of indirect support for research	• To encourage the exchange of information and spread of good practices on mechanisms aiming to stimulate private investment in research, particularly among SMEs, and innovation. • To respect Community State aid rules where measures constitute State aid.	• CREST set up in 2004/5, expert groups on R&D fiscal measures, to identify best practices and to set out guidance for the design, implementation and evaluation of R&D fiscal measures. • In 2006, the Commission adopted i) a new Community Framework for State aid for R&D&I, and ii) a Communication "Towards a more effective use of tax incentives in favour of R&D" accompanied by a Staff working document on "Good practice guidance for the design, implementation and evaluation of R&D tax incentives". • The Commission will promote the sharing of experience and good practices on the methodologies of evaluation of the effectiveness of R&D tax incentives by setting up in 2007 a network of national experts.	• Lack of consistent evaluation studies of national R&D tax incentives. • Absence of Community competence.
3.2. Development of effective tools for the protection of intellectual property	• To start the European [Community] patent as soon as possible. It must be readily affordable and comparable in cost to a European patent covering a limited number of countries. • To assess how the effects of disclosures prior to filing can be taken into account by European patent law (issue of "grace period"). • To improve the relevance and consistency of the intellectual property arrangements used to implement public research programmes.	• Several proposals for a Community patent were presented by the Commission but further progress has not been made. • "Grace period": Following two workshops organised by DG RTD in 2002, the Council working party on IP issued a statement recommending that EU Member States should introduce a grace period in their patent law, if this takes place in the context of an international harmonisation. A new international treaty (SPLT) being negotiated under the auspices of WIPO contains a provision which, if adopted, would oblige all WIPO Member States (including all EU ones) to introduce a grace period in their patent law. However, negotiation of this treaty is stuck (for other reasons). Nevertheless, a sub-set of the WIPO Member States are trying to reach an agreement on a more limited initiative, covering only four points of the SPLT, including the grace period. • A new Commission Communication on an "EU patent strategy" is in preparation. It will encourage progress regarding the Community patent and support the creation of a European patent judiciary hearing patent infringement and invalidity action. • The IPR and technology transfer-related issues tackled by the	• A Community patent system based on the March 2003 political agreement would lead to savings of only 20-30 % compared to the current European patent. • Concerning the Community patent, the main issues are i) problems regarding translations (into which languages does a Community patent need to be translated after grant? Does this concern only the claims of the patent? How binding are the translations?), ii) jurisdiction issues, and iii) to some extent, the role of the national patent offices.

		Commission after the adoption of the initial ERA Communication are much broader than those mentioned in the Communication. In particular, they include additional R&D-related IPR issues such as the experimental exception and knowledge transfer issues (concerning in particular university-industry relations).	
3.3. Encouragement of risk capital investment and company start-ups	• To step up initiatives to provide innovative start-up companies with the technical support and expertise they need to develop. • To encourage initiatives to bring scientists, industrialists and financiers at all levels into contact.	• The Commission issued guidelines on State aid for risk capital in 2001 and renewed them in 2006. The guidelines offer a framework for public funding of risk capital that follows market principles as much as possible and is supportive of markets rather than distorting. • On the Community level, direct investment into venture capital funds comes from the Community programmes (ETF Start-up Facility) and the EIF (the fund's own resources and those of the EIB under the Risk Capital Mandate). The Competitiveness and Innovation Framework Programme (2007-2013) will provide for funding of innovative SMEs. • On the demand side, the Commission organised a number of workshops in 2006 in relation to the issue of making potential recipient companies more aware of the possibilities to obtain risk capital financing and increasing their investment readiness by appropriate counselling and coaching.	• Barriers on both the supply and demand sides still hamper efficient deployment of risk capital, and more specifically early-stage venture capital in the EU. • The Single Market does not operate well in the area of risk capital: different regulatory and tax environments reinforce fragmentation of the risk capital market and inhibit cross-border operations.
4. A COMMON SYSTEM OF SCIENTIFIC AND TECHNICAL REFERENCE FOR POLICY IMPLEMENTATION			
4.1. Development of the research needed for political decision-making 4.2. Establishment of a common system of scientific and technical references	• The results of research undertaken as part of European programmes should be systematically exploited in support of the various Union policies and all the Union's research activities better co-ordinated in this respect. • A reliable and recognised system of validating knowledge and methods of analysis, control and certification also needs to be put in place and centres of excellence in Europe in the field	• In 2002 the Commission adopted guidelines and principles on the collection and use of expertise by the Commission services, in order to improve the knowledge base for better policies. • In order to promote a more efficient use of scientific information and expertise in support to policy making, the Commission is developing the web communication platform SINAPSE. • Via the Scientific Support for Policy –SSP- programme of FP6, the Commission has financed research projects aimed at meeting the needs of policy makers in different fields like agriculture, fisheries, crime prevention, environment protection, migration, etc. • The JRC functions as a reference centre of science and technology for the Union. Its institutes provide scientific information useful for the design, implementation and assessment of Commission services'	• The scope of scientific advice processes and the number of actors involved both as producer and user of advice and expertise is large making the establishment of a common system challenging. Work to establish common systems focussed on the identification of good practice and lessons learnt, as well as the identification of impact assessment practices only in a limited number of national systems. • The logistic support for the scientific advice activities provided by SINAPSE needs both time and resources to be developed. The human resources currently

	concerned networked.	policies. The JRC has also aims to produce socially robust knowledge and thereby contribute to enhancing the credibility and legitimacy of science inputs in public policy and social discourse. • The "Information Society Policy Link" initiative aims to ensure that policy development takes full account of the most recent and relevant developments emerging from ICT research. • "Science for Environment Policy" News Alert service aims to strengthen the links between science and policy by promoting easy-to-read new scientific information relevant to top priority environment policy issues. http://ec.europa.eu/environment/integration/research/research_alert_en.htm	allocated are insufficient.
5. MORE ABUNDANT AND MOBILE HUMAN RESOURCES			
5.1. Greater mobility of researchers in Europe 5.2. Introduction of a European dimension into scientific careers 6.3. Making Europe attractive to researchers from the rest of the world	• To encourage and develop the mobility of researchers both o geographically (through opening up recruitment of researchers at European level, and -in the frame of career assessment- proper valuation of experiences elsewhere in Europe), o and between the academic world and the business world (as an instrument of technology transfer). • To attract the best researchers from all over the world (through setting up of European grants for third-country researchers, encouraging the opening up of European and national programmes to third-country researchers and simplifying	• Two main achievements were: • the development, implementation and follow-up of the Recommendation on the European Charter for Researchers and Code of Conduct for their Recruitment, a landmark instrument for raising the awareness of and amelioration of career management and recruitment of researchers, • the development and adoption of the "scientific visa" package, a Directive and two Recommendations on the admission and residence (long and short-term stays) of third country national to carry out scientific research in the EU; proposed in March 2004, adopted in October 2005. • A number of tools for improved practical assistance to the researchers have been developed (e.g. Pan-European Researchers Mobility Portal with some 30 connected national portals on training and job-opportunities in research; European Network of Mobility Centres (ERA-MORE) with coordinated and customised assistance to researchers and their families in all matters relating to their mobility experience). • In the area of social security and taxation various surveys, awareness raising and training activities were carried out by the Commission and the Member States.	• Mobility is viewed as counterproductive both by the employer (loss of expertise) and by the employee (perceived lack of stability when moving). • Administrative and legal obstacles to mobility persist at national level; they are often situated outside the specific research sector and therefore outside the area of competence of those in charge of research policy. Progress could be made in the areas of (supplementary) social security and taxation. However competence of the Community is limited in these fields. • Inter-sector mobility is still hampered by predominantly cultural as well as practical issues (e.g. pensions). • Despite the significant attention that the Charter and Code have raised, there is evidence that many stakeholders are insufficiently aware of the issues at stake (this also impedes the actual uptake and implementation of Charter and Code

	regulations and administrative conditions applicable to admission and residence of third-country researchers), as well as to encourage the return to Europe of researchers who have left Europe, in particular for the United States.	• On the subject of inter-sector mobility information gathering and sharing of good practices have led to a better understanding of the issues at stake, while in 2006 a set of practical recommendations to various stakeholders was produced. • Marie Curie actions under FP6 and "People" programme under FP 7 have been / will be instrumental in meeting the above-mentioned objectives.	principles).
5.3. Greater place and role for women in research	• To stimulate discussion and exchanges of experience in this field among the Member States. • To develop a coherent approach towards promoting women in European funded research with the aim of significantly increasing the number of women involved in research.	• Establishment of ETAN – Experts Working Group on Women and Science, 'Enwise' Expert Group (*En*large *W*omen *I*n *S*cience to *E*ast), Helsinki Group on Women and Science, Working group on women in research decision–making. • A European Platform of Women Scientists was created in November 2005. Its purpose is to build a structural link between women scientists and research policy makers. • The "Gender Action Plan" (GAP) was an instrument available within FP6 to promote gender equality within projects. • Gender and science research is to be carried out at national and European level in FP7. A Help desk for Gender Mainstreaming will be created. Finally, an expert group on scientific excellence's evaluation criteria and gender bias will be created.	• Mental barriers: Frequently scientists perceive that scientific excellence and measures to increase the participation of women are not compatible. • No harmonised public data, which makes difficult interpretation and action on the European level.
5.4. Giving young people a taste for research and careers in science	The Member States and the Union should rapidly undertake a joint in-depth study of the room made for science subjects in education systems and how the teaching of sciences in the Union can be improved at all levels of education, primary, secondary and higher. Using the experience gained at national level, awareness-raising campaigns should be stepped up to create conditions conducive to the	Under the Science and Society action line of FP6 a number of actions were launched: • In 2004 a M€ 7.7 pan-European Initiative 'NUCLEUS' supporting science education was launched to develop and disseminate best practice. • A high level group on Increasing Human Resources for S&T in Europe was set up and its findings were published in 2004. The need for experience sharing in Europe on science curricula and teaching methodologies was stressed. • Two targeted calls for proposals were published in 2004 and 2005 covering these issues as well as the need to reinforce the transfer of research-based best practice into the classroom.	There is a delay in transferring research based innovation from the proof-of-concept stage to the classroom. Collective action at the European level is limited to activities that support the science curricula while respecting the principle of subsidiarity.

	sharing of experience and good practice.	• Actions have been taken to stimulate better coordination between organisers of science festivals. • A high level group chaired by Michel Rocard MEP will examine existing European collaborative activities in the field of supporting science education and identify best practice. Recommendations will be available in May 2007.	
6. A DYNAMIC EUROPEAN LANDSCAPE, OPEN AND ATTRACTIVE TO RESEARCHERS AND INVESTMENT			
6.1. Greater role of the regions in the European research effort 6.2. Integration of the scientific communities of Western and Eastern Europe	• To negotiate on the structural assistance planned for the years 2000 to 2006 in order to examine how best to combine projects implemented within this framework with projects undertaken in the European programmes • To put in place the conditions for research policies adapted to the socio-economic context of a regional territory and to strengthen the role that regions can play in establishing a more dynamic ERA.	• € 10.6 billion of cohesion policy funding, notably from the European Regional Development Fund, is estimated to be used to support R&D and innovation in the 2000-2006 programming period. This investment plays a significant role in fostering research and innovation activity, particularly in the Community's less developed Member States and regions, especially when the national, regional and private co-financing leveraged by cohesion policy programmes is also taken into account. Cohesion policy programmes offer a platform for regional stakeholders to increase their capacity to undertake excellent research and exploit its results. They are the EU's main instrument for fostering research activity in less developed Member States and regions and thus help to address the lack of cohesion and S&T development gaps identified as a problem in the ERA Communication of 2000. The Community Strategic Guidelines on economic, social and territorial cohesion 2007-2013 give an even more prominent place to R&D and innovation as a driver of economic growth. • Through its “innovative actions” programmes, cohesion policy has also supported the development of regional strategies in less favoured regions on the theme of knowledge-based technological innovation. Such strategies help regional stakeholders in less favoured regions to implement measures appropriate to their specific context. • The regional dimension of the European research effort is also acknowledged in the RTD Framework Programme. Positive results of the 'Regions of Knowledge' initiative launched in 2003 to promote more and better investment in research through mutual learning, coordination and collaboration among regional players has led to an extended 'Regions of Knowledge' activity in FP7. In addition, the new FP7 'Research Potential' action will focus explicitly on strengthening	• The Commission has tried to create a framework for co-ordination of cohesion and research policy with the proposals for cohesion policy programmes and the 7th RTD Framework Programme for 2007-2013. However, the different levels of governance mean that national and regional stakeholders are in practice responsible for co-ordinated use of the two instruments and for co-ordination of projects. A report on "How to achieve better co-ordinated use of the EU Structural Funds and the 7th Research Framework Programme to support R&D" will be delivered in early 2007 in the framework of the CREST mutual learning process between Member States.

		research capacity in 'convergence regions' and 'outermost regions' in terms of physical and human capital.	
6.3. Making Europe attractive to researchers from the rest of the world	See 5.1., 5.2.		
7. AREA OF SHARED VALUES			
7.1. Tackling science/society issues on a European scale	To organise "Citizens' Conferences" at European level [NB: This has been extended to other techniques aiming to raise the participation of citizens and civil society organisations to research and research based policies]	• The Science and Society Action Plan, adopted in 2001, lists 38 actions aiming to close the gap between citizens and science policy makers, and to place science at the heart of policy making. • A study and a conference set the scene for Commission's action in the field of governance through policy recommendations (IFOK GmbH study), and 19 projects were selected for financing by the FP6 Science and Society line. • Two real size experiments on participation ("Consensus Conference") were organized in 2005 and 2006 (one in Brain Science, another in the field of Urban Development). • A European platform of stakeholders and experts in participation has been created (Citizens Participation in Science and Technology - CIPAST). It has produced a reference database gathering cases of participation in Europe and is aiming to produce, and use, a training package. • FP7 Programme Implementation: Based on the lessons from FP6, support to participation of Civil Society Organisations (CSOs) and preparation of pilot Co-operative Research Processes (CRPs) will be provided as well as training for policy makers at European level. A new instrument for the benefit of CSOs as specific groups has been created (BSG-CSOs). Co-operative Research Processes could be the embryo of a specific European way to "define and implement research priorities, engaging citizens and respecting common ethical norms".	At Member State level there is not always a counterpart to the Science and Society activity of the Commission. The open coordination initiated in 2001 has therefore not been successful.

7.1. bis	To develop more consistency in foresight exercises at national and European level and within the framework of the numerous existing networks. To establish a platform for exchange, to create points of synthesis and to align methodologies. To better use the results of foresight exercises for policy decision making.	• Setting up of trans-national networks between sponsors and practitioners of foresight (for instance, a network of national representatives on foresight meeting twice a year to exchange information and best practices). Organization of "mutual learning workshops" addressing both policy-makers and foresight practitioners in Member States. • Development of tools, for stakeholders, including regional stakeholders, wishing to launch foresight initiatives. The FOR-LEARN web site (http://forlearn.jrc.es) is providing a Support to Foresight practitioners" and an "Online Interactive Foresight Guide" supports the new comers in foresight considering designing, running and using a Foresight exercise. • Setting up of a monitoring system on foresight in Europe (EFMN), with a web EFMN portal (www.efmn.info) as dissemination tool.	• The direct impact of foresight studies on decision making on Science and Technology in the Member States and in the Commission cannot easily be measured. Impact on decision making is likely to have been indirect. • Potential users in the Commission and in the member countries are insufficiently aware of the potential of Foresight as a policy tool. • The community's reluctance to embrace new actors and innovation may be a limitation to the use of Foresight as a policy tool. Private sector expertise is insufficiently used. • Several factors explain why foresight activities have not yet reached the same state of integration and coherence at EU level as many other policy fields: • Foresight activities are embryonic or relatively weak in some Member States; • The main Foresight work is often done in national settings and targeted to specific issues. Players pursue contacts at EU level mostly on an ad-hoc basis, if at all; • European policies and issues are not systematically taken into account in national and regional Foresight studies.
7.2. Development of a shared vision of ethical issues in	• The links between the ethics committees established at national and European levels should be strengthened.	• The Forum of National Ethics Councils (NEC Forum) was formed in 2003, as an independent informal platform for exchange of information, experience and best practices. An electronic database of opinions of NECs has been established.	• A central challenge is that the EC has no formal competence to harmonise ethics in member states; it is the realm of subsidiarity.

science and of technology	• To help make for mutual understanding of points of view and the development of harmonious approaches there should be encouragement to open up the various national committees to experts from other European countries. • The rules in force and the criteria on ethics used in national and European research programmes should be compared with a view to alignment around shared principles and respect for differences in sensitivities and opinions.	• A network of Research Ethics Committees (RECs, i.e. committees which evaluate, at local and regional level, any type of research protocols involving human beings) was established in 2005 to enable mutual learning and exchange of experiences (European Network of Research Ethics Committees – EUREC). • A number of conferences, studies and workshops and have been organised to stimulate international dialogue, map existing rules and practises, identify best practise and encourage capacity building. Also a number of FP6 research projects focussing on ethical frameworks for new technologies have been funded. • The Ethical Review of projects submitted under FP6 has been fully implemented.	• Ethics is deeply embodied in national cultures, and on a number of issues opinions diverge significantly. • The institutional infrastructure to address ethical issues in most member states would benefit from networking opportunities and exchange of best practice as foressen in the EUREC and NEC Forum's activities • Ethical issues in science often internally divide 'traditional' forms of organised representation such as political parties or consumer organisations. It is therefore difficult for representatives from such stakeholders to speak with a clear mandate on ethical issues in science. • Increasingly, frontier research activities take place in an international environment beyond the control of Member States (and EU) influence.
8. Developing an ambitious and extensive programme of international S&T co-operation[193]	• Opening the European Research Area up to the rest of the world	• S&T agreements promote interaction between the participants' knowledge systems and create excellent conditions for: Europe's access to knowledge systems in partner countries to tackle problems of common interest. Such agreements also safeguarding intellectual property rights. Furthermore, bi-regional and bilateral dialogues have been established where an agreement is not in place. • New applicant countries have been associated to the Framework Programme providing full rights and access for co-operative research with Member States. • The number of 3rd countries where dedicated EC science counsellors are located has been increased with the addition of Brazil, Israel, Egypt, Russia.	• Changes in the EC management of FP international co-operation projects resulted in the targets for international participation in EC funded research not being met in FP6. Efforts were made to improve this situation by, for example, dedicated international co-operation calls for proposals. • S&T agreements with emerging economies (Argentina, Brazil, Chile, Mexico, Russia, India, China, South Africa) do pose some problems. Cutting-edge S&T may not address the development requirements of the majority

[193] Objectives and actions as defined in COM(2001) 346 *'The international dimension of the European Research Area'.*

			of the population of these countries. Reciprocity clauses of these agreements give researchers in both partners access to each others' research funding. Take up of these opportunities by European scientists is severely limited by funds available in partner countries.
	• Focusing EU efforts on specific objectives	• Through the CREST mechanism a working group has been established in 2007 which is working towards producing an inventory of international S&T co-operation activities conducted by the Member States. • As a result of INCO activities, research capabilities in partner regions have been strengthened. • Technology platforms established during 2005-6 have helped to provide industry centred strategic research agenda but these, with some exceptions such as the Global Animal Health TP, have not considered international co-operation in great depth.	• At present there is no mechanism to determine horizontal international co-operation priorities across and between thematic areas of the Framework Programme. • Furthermore, only a few Member States have determined their own national strategies in this area hence there is also no explicit European mechanism to determine priorities. • The scale of the INCO programme in relation to the challenges faced is insufficient to have longer-term institutional effects on a larger scale
	• Stepping up international 'technology watch' activities	• ERA-NETs with particular focus on international co-operation have been established for some regions (e.g. the Mediterranean, Balkans, China, etc). • The ERAWATCH network is also of relevance here (section 2.1) • The mission of the DG-JRC Institute of Prospective Technological Studies (IPTS) is to provide prospective techno-economic analysis in support of the European policymaking process and includes consideration of developments in 3rd countries.	• Limited effort is devoted to technology watch actions across Europe.
	• To align EU scientific co-operation policies with EU foreign policy and development aid programmes	• Research is an important component of EU external policy and cross references to research actions are made in relevant EU external policy initiatives.	• No formal mechanism currently exists by which an overview of coherence of potential external policy actions and international research co-operation can be assessed.

	• Enlisting EU scientific and technological capabilities to deal with world problems	• The conclusion of the ITER agreement which brings together the European Union, Japan, the People´s Republic of China, India, the Republic of Korea, the Russian Federation and the USA, places Europe at the forefront of nuclear fusion research. • The EC is supporting a long-term partnership between Europe and Developing Countries by providing €200 million for the development of new medicines and vaccines against HIV/AIDS, malaria and tuberculosis (TB) in the European and Developing Countries Clinical Trials Partnership (EDCTP). It brings together EU Member States plus Norway, Developing Countries, other donors and industry in a joint effort to combat poverty-related diseases through more and better structured research and development that meets the needs of the populations in need.	• Currently no mechanism (outside the Framework programme) exists to jointly identify which global issues are appropriate for an EU response or how such a response could be organised. • Several potential frameworks for enlisting EU S&T exist (e.g. various UN fora).