COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 6.4.2005
SEC(2005) 430

COMMISSION STAFF WORKING PAPER

Annex to the

Proposal for the Council and European Parliament decisions on the 7th Framework Programme (EC and Euratom)

Main Report: Overall summary

IMPACT ASSESSMENT AND EX ANTE EVALUATION

{COM(2005) 119 final}

TABLE OF CONTENTS

1. Introduction

This report presents the overall summary of the impact assessment of the European Commission's proposals for the European Parliament and Council decisions on the 7th Framework Programme (EC and EURATOM), the Specific Programmes and the Rules for Participation. The FP7 impact assessment was based upon inputs from stakeholders, internal and external evaluation and other studies, and contributions from recognised European evaluation and impact assessment experts. The in-depth analysis (Annex 1) upon which this summary is based is contained in the annex, and references are made systematically to the relevant sections of the annexed report so that the reader can find the more detailed material.

Although ambitious in its attempt, the report also comes with a note of warning: assessing the impacts of research policy is particularly difficult. First, it is hard to establish a linear causal relationship between specific policies and particular effects. The reason is that there exists an important time lag between doing research, generating innovations, and reaping commercial benefits. Different policy actors also play a role and their policy instruments generate effects at different times. Second, difficulties arise when trying to quantify many predominantly qualitative effects such as increased networking, improved absorptive capacity, strengthened research competencies of firms, and changed behaviour. Hard data need to be cross-checked with 'soft' information to be obtained from interviews, case studies, expert views etc. Focussing only on monetary effects or private returns to intervention ignores the importance of social returns or 'externalities' (e.g. knowledge spill-over effects), which normally justify the intervention, but which are harder to measure.

2. What issues are the proposals expected to tackle?

The world economy and society are transforming. A new international division of labour is emerging, with the rise of players such as Brazil, Russia, India and China (the so-called BRIC economies) and the increasing globalization of production; new sources of competitive advantage and new sectors are being created based on innovative technologies such as biotech, ICT and nanotech; the distribution of power and leadership, and institutions of governance are evolving (Annex 1, Chapter 1, Section 1).

2.1 Economic, social and environmental challenges

As highlighted in the Kok Report, Europe is not adapting well to the aforementioned changes. It is confronted with a number of serious challenges:

- European economic growth needs to be boosted;
- European competitiveness – as reflected in standards of living, labour productivity, de-industrialisation, or high-tech exports – needs to be improved;
- More and better jobs need to be created in a sustainable way in the high-tech and knowledge intensive sectors;
- Cohesion needs to be improved in the face of the challenges posed by ageing and enlargement (Annex 1, Chapter 1, Section 1);
- Europe is also faced with **environmental challenges** in the areas of climate change, water quality, biodiversity loss, food production and soil degradation, over-fishing, deforestation and air pollution (Annex 1, Chapter 1, Section 2);

- Finally, Europe is confronted with **social challenges** as it still suffers from sub-optimal access to education, poverty, serious diseases, rising health costs, and problems affecting the quality of life (Annex 1, Chapter 1, Section 3).

2.2 Weaknesses of the European research system

S&T can bring solutions in each of these areas (Annex 1, Chapter 1, Sections 1, 2 and 3). But Europe is finding it difficult to meet these challenges because its research system suffers from a number of key weaknesses (for more detail see Annex 1, Chapter 2):

- It suffers from an important R&D investment gap vis-à-vis its main competitors, even though they are increasing investment rapidly, new fields of science have emerged, and the cost of R&D is rising;

- It has too few researchers in its labour force, despite being a major producer of S&T graduates;

- It is excellent in science but needs to invest more effectively to maintain its level;

- It needs to become better at transforming the results of research into commercially valuable innovations;

- It needs to exploit its S&T better in order to improve its competitiveness, especially in terms of selling new products abroad;

- The European research area is not yet sufficiently well organised, making it unattractive, and resulting in net outflows of R&D investment, students and researchers.

The conclusion is that an FP is needed that is substantially larger than FP6 in order to be able to address important weaknesses in the European research system. In addition, the emergence of new and the intensification of existing economic, social and environmental challenges demand a European approach. However, in terms of structure and thematic orientation a sophisticated balance should be struck between continuity and change as compared to FP6. Europe therefore needs to invest more in research, and to do so more effectively. It must open up further by encouraging a greater pooling of knowledge and resources across frontiers, stimulate the mobility of researchers and better coordinate its national research efforts so as to reduce fragmentation and diversification of funding.

3. What would happen under a “no policy change” scenario?

Under a “no policy change” scenario the specific and systemic weaknesses of the European Research Area would only be partially addressed, and consequently the speedy achievement of key EU policy objectives would be endangered. This is notably the case for the achievement of the Lisbon Agenda, the centre piece of the Barroso Commission’s strategy. It would also send a discouraging message to Member States who are currently committed to increasing their investment in R&D. In particular:

- Europe would remain a laggard in terms of economic growth;

- European competitiveness – as reflected in standards of living, labour productivity, high-tech exports, etc. – would continue to decline;

- Far fewer high-quality jobs would be created;

- It would become more difficult to achieve cohesion;

- It would become harder to address environmental challenges;
- Important opportunities would be lost to confront social challenges;
- And the attractiveness of the European Research Area would continue to decline.

[See Table 3 and Annex 1 (Chapter 5, Sections 2 and 3)]

4. Which European S&T system actors and stakeholders would be affected?

It is in the first place the community of individual researchers and of companies, universities and research institutions carrying out research that would be positively affected by addressing the specific and systemic weaknesses of the European S&T system. This community is located in companies of all size classes, in more as well as less advanced regions, and in all 25 EU Member States. Via their contributions to the achievement of the Lisbon objectives, actions at EU level in the field of S&T also have the potential to affect the lives of all European citizens. The impacts of EU level S&T actions spread beyond the EU-25, however, as they affect the global research community (as participants) and societies worldwide (as beneficiaries).

5. What main objectives are the proposals expected to reach?

The FP7 proposal sets out to achieve a number of objectives of critical importance for EU policy. Two key objectives are:

- It aims to contribute to meeting the policy objective set at the European Council meeting in March 2000 to make Europe the most competitive and dynamic knowledge society in the world by 2010.
- It sets out to support progress towards the targets established at the European Council meeting of March 2002, held in Barcelona, which specified that the EU should invest 3% of its GDP in R&D by 2010, of which two-thirds should come from the private sector and one-third from the public sector.

More specifically, the proposal is designed to address the following more detailed policy objectives listed the Communication on the future of Community research policy (COM(2004)353) published in June 2004:

- To enhance the competitiveness of European industry by the common technology initiatives;
- To increase European wide S&T collaboration and networking for sharing R&D risks and costs;
- To contribute to an increase in the level of research investment (contribute to the realisation of the 3% Barcelona objective by more than doubling Community investment in R&D);
- To improve the coordination of European, national and regional research policies;
- To strengthen the scientific excellence of basic research in Europe through increasing coordination and competition at the European level;
- To promote the development of European research careers and to make Europe more attractive to the best researchers;
- To provide the knowledge-base needed to support key Community policies;

- To increase availability, coordination and access in relation to top-level European scientific and technological infrastructure.

6. Has account been taken of any previously established objectives?

6.1 Existing objectives and commitments

In addition to the objectives outlined in the previous section, the proposal is based upon the long-standing objectives of Community research policy as stated in the Treaty, which include the implementation of research, technological development and demonstration programmes, by promoting cooperation with and between undertakings, research centres and universities; the promotion of cooperation in the field of Community research, technological development and demonstration with third countries and international organisations; the dissemination and optimisation of the results of activities in Community research, technological development and demonstration; the stimulation of the training and mobility of researchers in the Community; the promotion of coordination of research and technological development activities in the Union; and cooperation in Community research, technological development and demonstration with third countries or international organisations.

FP7 also takes into account other commitments, for instance those made in Göteborg, and the Sustainable Development Strategy. Care has also been taken to ensure coherence between the Framework Programme and **complementary policies** such as the structural policies and the Competitiveness and Innovation Framework Programme.

6.2 Learning from past experience

The new Framework Programme builds upon **past experience with the FP** (Annex 1, Chapter 4). Notably, the recent Five Year Assessment (1999-2003) showed that the Framework Programmes have provided a major contribution to Europe's knowledge base and the restructuring of Europe's research system to be more innovative, with a tremendous effect on networking. Through the FP, Europe has successfully supported European S&T in the past. From FP2 to FP6, the FP has experienced significant change. The budget has been increasing, and more projects and participations funded. Priorities have become more diversified. Over time, the participation and funding of different actors in the innovation system has become more balanced. By involving an ever larger number of EU member states, collaborative research consortia have an increasingly integrating effect. All EU member states are able to achieve knowledge returns from participating in FP projects that far exceed their investment in the FP, and FPs have now become increasingly attractive to scientists from all over the world.

The past FPs have had wide-ranging impacts on Europe's scientific, technological and economic performance. Past FPs have had a positive impact on scientific output. Each collaborative research project generates on average up to 9 peer reviewed scientific publications, most of them international co-publications. Recent evidence has also shown that the scientific impact of publications from EU funded work has for two out of the three fields studied, been higher than other publications. The FP has also had a beneficial effect on the production of innovative outputs such as patents, new tools and techniques, the design and testing of models and simulations, the production of prototypes, demonstrators and pilots, etc. Firms that participate in the FP are, for instance, more likely to be innovative, to apply for patents and to hold patents than firms that do not participate. The FP also generates what is called "behavioural additionality", that is, FP participants are more likely to continue to carry out research in the future and collaborate in doing that. The results from FP funded research are well exploited economically, and in many cases give rise to important commercial impacts such as increased turnover, higher productivity and profitability, larger market shares, and access to new markets.

The FP has an important structuring effect on the European research and innovation area. Collaborative research projects, networks of excellence, and Marie Curie actions create strong interregional and international links, both between institutions and between individual researchers. Inter-governmental cooperation at the programme level has also been strengthened through instruments such as ERA-net.

The FP has other major impacts too. The FP also has direct and indirect impacts on society and the environment. S&T advances generated by the FP lead to economic benefits (through enhanced innovation, competitiveness, growth, etc.) which in turn put Europe in a better position to face social and environmental challenges. In addition, FPs have increasingly devoted direct attention to social and environmental objectives. The results of FP funded research projects also constitute a critical input into the development of wider EU policy in a variety of fields (for example, from fisheries to energy, transport and the environment), while community research policy strengthens the EU as an international actor, e.g. as frontrunner and leader in international negotiations.

7. What are the main policy options available to reach the objective?

In examining policy options, **3 key factors** were taken into account. Firstly, FP7 should be tailored to European S&T needs: acting as an instrument to promote Lisbon and other key policies, while addressing the specific needs of the diverse research players, and having a strong EU added value. Secondly, it should reply to the strong demand for new actions in the fields of industrial and basic research. Thirdly, it should respond to stakeholders' requests for a more user-friendly and outcome-based FP.

Three basic policy options are assessed (Annex 1, Chapter 5, Section 1). The assessment focuses on their economic, social and environmental impacts, and the extent to which each option takes account of the three key driving factors above.

⇒ The **first policy option** is the do-nothing option. It serves to analyse whether without EU intervention it is possible to reach the same objectives. It relates to a policy of no financial intervention at EU level in the field of research and technological development (discontinuation of FP). It is an essential benchmark for demonstrating the full added value of the FP7 proposal (option 3), which cannot be deduced simply from its marginal effect in relation to the status quo (option 2).

⇒ The **second policy option** is the business as usual option. It would mean launching FP7 as a continuation of FP6, with the same budget allocations, the same objectives, the same institutional actors, the same research priorities, the same instruments, etc. The premise underlying this option is that FP6 can adequately address the major challenges facing Europe in the next few years without introducing any major changes to its size, structure and organization. This option also responds most clearly to the important concerns about continuity and stability of EU research actions.

⇒ The **third policy option** is the proposed FP7 option. It concerns a restructured Framework Programme, twice as large as FP6, and designed so as to better respond to the targets set at Lisbon. It starts from the observation that circumstances have changed very significantly since the launching of FP6, and proposes an action that builds upon the accomplishments of FP6, but is characterised by a new scale, scope and ambition. Within this option certain important choices had to be made, and these are also analysed.

Under this third policy option, ***9 different sub-options*** have been carefully assessed in comparison with ***2 reference scenarios***. For a detailed overview of the assumptions underlying the 2 reference scenarios and each of the 9 different sub-options, please see Appendix 1 in the attached in-depth report (Annex 1). The differences between the different sub-options relate to, for instance, the rate of growth of FP funding after doubling funding under FP7 (e.g. moderate growth vs. continued rapid growth), or the criteria on the basis of which FP funding will be allocated to countries and sectors (e.g. share in EU R&D expenditure vs. scientific/innovative performance). The number of scenarios that could be imagined with regard to the ***size*** of the FP is without limit: increasing FP funding under FP7 by 25 percent, 50 percent, 75 percent, etc. Here, however, we have focused on the three aforementioned basic policy options (do-nothing, business-as-usual, doubling the size of the FP) and on providing in this way a range of minimum and maximum impacts.

Several **management options** have been examined too. These include the direct execution of the Framework Programme by the research DGs (status quo), the establishment of Commission executive agency(ies) to implement parts of the programme, and the establishment of joint undertakings or other structures (as foreseen in Article 171 of the EC Treaty and its Euratom equivalent) for the implementation of other parts. In addition, management in association with the Member States has been considered for certain actions. (Annex 1, Chapter 6, Section 1).

Further use of the provisions of articles 169 and 171 of the Treaty will be used for the implementation of certain actions.

Table 1: Characteristics of the various management options available for FP7

Direct Management by Research DGs	***Executive Agency***	***Other Structures***	***Management in association with the Member States***
Direct management is essential where there is a close link between the activity and policy formulation, or where the tasks require discretionary powers in translating political choices into action. Direct management is not essential for tasks that are purely administrative or that could be better managed locally through shared management with the Member States.	Executive agencies may be entrusted with tasks that are required to implement a Community Programme (with the exception of those tasks requiring discretionary powers in translating political choices into action and where feedback from the actions are relevant for policy orientations). Executive agencies are particularly suited to performing administrative tasks in the implementation of a programme; thus freeing Commission staff for the performance of core tasks including policy.	Joint undertakings or other structures for implementing research actions may be set up under Article 171 of the Treaty. The role of the Commission's services within the structure would be decided on a case-by-case basis at the time that the structure is created. Article 169 of the Treaty also foresees the possibility of participating in structures created for the execution of research and development programmes undertaken by several Member States. These structures would involve a significant proportion of management outside of the Commission's services.	Delegation of certain elements of the FP management to public bodies established in the Member States is most appropriate for actions that would benefit from being performed locally, where there are no links between individual grants and policy formulation and where there is sufficient national structural capacity. In the case of Community research, management by such bodies could be considered in cases where the actions involve projects with established participants only in one Member State. Delegated management with the Member States is not appropriate for actions involving multi-national teams, where funds can not be allocated to national programmes or where the policy area is also targeted at non-member states
Direct management should be retained for the major funding decisions and for the project management in the case of collaborative research.	An executive agency could perform many of the "upstream" tasks relating to programme implementation as well as "downstream" tasks in those areas where the outcome of individual projects is not critical to the shaping of future research policy (this could apply to parts of the Human Resources and Mobility activities and SME-specific support actions). An executive agency could provide a suitable vehicle to support the implementation of the European Research Council projects.	Article 169 applies to Community participation in national programmes. Article 171 allows for the creation of joint undertakings or other structures and could be used for the implementation of technology initiatives and for new infrastructure actions.	Detailed implementation of the individual grant schemes for the co-funding of national mobility programmes could be entrusted to the appropriate national or regional bodies.

Trade-offs have centred upon finding appropriate balances in the provision of support to different stages in the S&T process and different thematic priorities; between continuity and change in terms of instruments; and between accountability and impact on the one hand and simplification and rationalisation on the other hand.

8. How are subsidiarity and proportionality taken into account?

The **subsidiarity** principle is intended to ensure that decisions are taken as closely as possible to the citizen and that constant checks are made as to whether action at Community level is justified in the light of the possibilities available at national, regional or local level. Specifically, it is the principle whereby the Union does not take action (except in the areas which fall within its exclusive competence) unless it is more effective than action taken at national, regional or local level.

In designing the proposal, this principle has been carefully considered and respected. It has first been established that government has an important role to play in improving Europe's S&T. Governments across the world intervene in the field of R&D because of the existence of market and systemic failures. However, substantial attention needs to be paid to a careful policy design, for example, the choice of key areas for intervention, and the most effective instruments to deploy (e.g. fiscal incentives, direct subsidies). Support also has to be provided at the correct policy level.

Furthermore, it has been found that **intervention at EU level is fully justified**. There are a number of cases where it can be more effective to provide support for research at EU level than at national level. Some research activities are of such a scale that no single Member State can provide the necessary resources and expertise. In these cases, EU projects can allow research to achieve the required "critical mass", while lowering commercial risk and producing a leverage effect on private investment. EU-scale actions also play an important role in transferring skills and knowledge across frontiers. This helps to foster excellence in research and development through enhancing capability, quality and EU-wide competition, as well as improving human capacity in S&T through training, mobility and European career development. EU support can also contribute to a better integration of European R&D, by encouraging the coordination of national policies, by the EU-wide dissemination of results, and by funding research for pan-European policy challenges (Annex 1, Chapter 3).

The principles of **proportionality** and necessity, which require that any action by the Union should not go beyond what is necessary to achieve the objectives of the Treaty have also been taken into account. Given the extent of the economic, social and environmental challenges Europe is facing, the substantial increase in resources proposed is justified. It should generate substantial positive impacts through crowding-in and economic multiplier effects.

9. What are the impacts expected from the different options identified?

9.1 Expected impacts of the FP7 key actions

In the field of research **cooperation**, the substantial increase proposed under FP7 will be crucial in distributing more widely the significant effects on restructuring research in the EU, and on pooling and leveraging resources, and will move Europe closer to a real "single market" for research. The proposed simplification of rules and procedures of FP7, notably in relation to proposals for research consortia, will also have a significant impact in making the FP easier for applicants and participants, and thus more attractive and useful to the research community. On the other hand, ending the collaborative research programmes carried out under the FP would lead to greater fragmentation and inefficiency of research efforts in Europe, while continuing FP6 would be a missed opportunity to further restructure the EU research system and reduce its inefficiencies [See Table 3 and Annex 1 (Chapter 5, Section 2)].

The implementation of **Joint Technology Initiatives** will contribute to the achievement of the Lisbon competitiveness objective and the Barcelona targets for research spending. The contribution to Lisbon will be made through identifying areas critical for European competitiveness and supporting ambitious, research agendas, which will be strategic and long-term in nature, and will take into account wider policies and issues relevant to research and exploitation. They will involve the commitment of massive financial, organisational and human resources through public-private partnerships, and will result in new and more competitive products and processes, European leadership in these areas, the tying down of those industries to Europe, and enhanced competitiveness in world markets. The contribution to the achievement of the Barcelona objectives lies in the large-scale mobilization of resources, one-third of which would be financed by the public sector and two-thirds by the private sector [See Table 3 and Annex 1 (Chapter 5, Section 2)].

Scaling up funding for breakthrough research (**'Ideas'**) to European level will increase competition and drive up the quality of research proposals, leading to higher levels of excellence in Europe's basic research. This will result in a better and enlarged knowledge base, which will have direct economic, societal and environmental benefits, and can be exploited by European enterprises to generate innovative products and process. The creation of the ERC and the introduction of a European-level funding scheme would also lead to a levelling-up of standards and have important structuring effects (improving the dissemination of results and increasing attractiveness) [See Table 3 and Annex 1 (Chapter 5, Section 2)].

As a result of the different actions envisaged to support researchers (**'People'**) under FP7, it can be expected that more research will be carried out in Europe, and that research will generally be of higher quality, will be more inter-disciplinary, and will better take into account industry orientation where appropriate. This will be the result of actions with a structuring effect throughout Europe on the organization, performance and quality of training and researchers' career development. These actions will make scientific careers more attractive for European citizens (in particular women), will make Europe more attractive to the best foreign researchers, will increase the level and diversity of skills of individual researchers, will introduce sustainable pathways between academia and industry (including SMEs) and between disciplines, will unlock the potential and thereby improve the capabilities of scientific institutions (in particular in the convergence regions of the EU and in the candidate countries), and will network individual researchers and scientific institutions [See Table 3 and Annex 1 (Chapter 5, Section 2)].

For a number of actions enhancing research **capacities** (Research infrastructures; Research for the benefit of SMEs; Regions of knowledge; Research potential; Science in society; Specific activities of international cooperation), the approach proposed for FP7 would build upon the success of activities undertaken under FP6 and increase their impacts [See Table 3 and Annex 1 (Chapter 5, Section 2)].

Proposed themes (Health; Food, Agriculture and Biotechnology; Information and Communication Technologies; Nanosciences, Nanotechnologies, Materials and new Production Technologies; Energy; Environment (including Climate Change); Transport (including Aeronautics); Socio-economic Sciences and the Humanities; and Security and Space) will help unlock hidden economic potential, meet Europe's environmental challenges, fulfil European policy objectives and contribute to improvements in European citizen's lives. Special attention will also be paid to the horizontal integration of priority scientific areas which cut across themes [See Table 3 and Annex 1 (Chapter 5, Section 2)].

9.2 Overall economic, social and environmental impacts

In order to estimate the possible **aggregate economic impacts** of the FP7 proposal, an econometric model was used. Various scenarios were simulated for long-term trends in FP funding and national/sectoral flows of financing (for a detailed presentation of the model, its scenarios and assumptions, see Annex 1, Appendix 1). On the basis of this modelling, it is concluded that the estimated aggregate economic impacts of FP7 are large [See Table 3 and Annex 1 (Chapter 5, Section 2)]. Compared to its modest share of European public R&D funding, the FP achieves significant impacts, especially in the long-term, mainly because of high crowding-in and economic multiplier effects. The proposed doubling of FP7:

- Will boost Europe's economic growth. Depending on the rate of growth of FP funding after FP7, doubling FP funding would generate at least 0.45 and up to 0.96 percent of extra GDP over and above the business-as-usual scenario of moderate growth in FP funding by the year 2030. In other words, assuming a GDP of 100 under the business-as-usual scenario for the year 2030, and given that the extra GDP generated by doubling FP funding would amount to from 0.45 to 0.96 percent of GDP by that same year, then total GDP would reach between 100.45 and 100.96 in the year 2030. Given the comparatively small size of the FP this constitutes a large impact. When correcting for quality - i.e. taking account of the fact that as a result of technical progress the quality and capabilities of products increase significantly - the impacts on European economic growth are larger still. Doubling FP funding would then generate at least 0.69 and up to 1.66 percent of extra GDP over and above the business-as-usual scenario of moderate growth in FP funding;

- Will create extra jobs for European citizens (up to 925,000 extra jobs by the year 2030, of which up to 215,000 in research);

- Will raise Europe's competitiveness (extra-European exports are increased by up to an extra 0.64 percent by the year 2030, imports reduced by up to 0.3 percent), and increase Europe's R&D intensity (the extra growth in Europe's R&D intensity could reach 0.2 percent).

The FP is more effective than national funding in reaching these results. On the other hand, under the no framework programme option:

- Europe would lose up to 0.84 percent of GDP by the year 2030 compared to the business-as-usual scenario and up to 800,000 jobs, 87,000 of them research-related;

- Extra-European exports would be lower by 2 percent and imports higher by 1.85 percent;

- Europe's R&D intensity would be lower by 0.09 percent, making it harder to achieve the 3 percent objective.

The proposed FP7 has large potential **aggregate social impacts**. It will contribute to the achievement of the Lisbon strategy and to addressing the main future social and political challenges of Europe. Through both thematic efforts in diverse areas as e.g. industrial technologies, energy, transport, ICT, food, agriculture, fisheries, maritime affairs, water management, life sciences, etc., as well as through research that directly aims at the advancement of Social Sciences, FP7 can further enhance issues such as health and safety, social cohesion, human capital, well-being, governance, human rights and ethics, self-sufficiency, equity, etc. Therefore, the new research effort in FP7 will enhance the impact of innovation and competitiveness, both on individual economic entities but ultimately also on the quality of life in the society as a whole. Research on ethics at European level is critical for arriving at a responsible approach towards S&T, which is consistent with the European Charter of

Fundamental Rights and reflects public sentiment [See Table 3 and Annex 1 (Chapter 5, Section 2)].

The Lisbon Agenda and the ERA clearly identify the need for innovative and competitive technological progress in line with environmental and socio-economic needs. Advances in knowledge and innovation further sharpen the competitive edge of societies which possess the know-how and capacities and have become key factors in decoupling economic development from adverse **environmental impacts**. To address the different challenges, research and technological development affecting the environment in FP7 should aim to identify win-win technologies, improve natural resources management and services and understand and predict the environment more precisely. Furthermore, FP7 should recognise the need for research activities for the analysis of sustainable development, scenario building and impact assessment. Cross-cutting enabling technologies, such as nanotechnology, biotechnology and industrial technologies can also have a positive environmental impact [See Table 3 and Annex 1 (Chapter 5, Section 2)].

As far as the **time dimension** associated with these impacts is concerned, while showing significant results in the short term, investment in research shows its greatest impacts in the medium to long term as it takes time to transform research results into new products and processes (Annex 1, Chapter 5, Section 3).

As far as **impacts on particular groups** are concerned, care has been taken to make sure that all players in the European S&T system, including SMEs and the new Member States, will benefit to the maximum extent possible from the implementation of the FP. EU scientific achievements have a significant global impact – notably in developing countries, the Mediterranean, the Western Balkans and newly independent countries of the former Soviet Union – and cover key areas such as agriculture, human health, food processing, post-harvest conservation, water treatment, erosion and environmental protection.

10. How will the policy be implemented, monitored and evaluated?

All efforts are being made to ensure that FP7 will be more easily accessible to all participants and more user-friendly. Procedures will be streamlined for FP application, and the requirements and procedures for contract negotiation and project reporting will be improved. The effective management of the enlarged Framework Programme will be ensured by means of new innovative management structures (Annex 1, Chapter 6, Sections 1 and 2).

Because of the proposed large increase in the FP7 budget, and its aim to make a substantial contribution to the achievement of the Lisbon, Göteborg, Barcelona and other Community objectives through the effective use of EU funds, it is crucially important to continue to improve the FP evaluation and monitoring system by setting clear and measurable objectives and regularly tracking progress towards their achievement. Moreover, a set of objectives and indicators and a sound monitoring and evaluation system is a requirement of the Financial Regulation (article 27, paragraphs 3 & 4) for all expenditure programmes (and must be set out in the **ex-ante evaluation**). Improvements will be made to the data collection and analysis system and to the broad evaluation and monitoring approach. Full details of the new programme evaluation and monitoring system can be found in Annex 1, Chapter 6, Section 3.

It is proposed that the new FP be built on a robust hierarchy of logically interdependent outcome **objectives** with a limited number of realistic and appropriate **indicators**. Indicators will be both quantitative and qualitative, as well as progressive to show the path or direction of changes to be expected, in order to allow for tracking of progress. They will be complemented by management and output indicators in order to monitor progress during the lifetime of the research activities.

Monitoring of implementation management would be ensured by operational senior management within the Commission on a continuous basis with annual check points and using a common set of management performance indicators. Adequate resource would be given to this process. The annual results of this exercise will be used to inform senior management and as an input to the ex post assessment exercise.

An interim evaluation of the FP would be carried out by independent scientific panels which would assess the quality of the research activities, progress towards the objectives set and the scientific and technical results achieved. Such an interim evaluation of FP7 (of 7 years duration) would therefore take place 3-4 years after the start. It could be complemented by a similar exercise at the end of the programme to feed into the ex post assessment (see below).

A **coordinated programme of studies** should be developed for: horizontal assessments of such topics as the impact of research on issues such as productivity, competitiveness and employment; structuring effects of the FP on the ERA (fragmentation, excellence, coordination) through the formation and development of commercial and knowledge networks, and the creation and support to infrastructures; and the impact of Community research on strategic decision making in companies and research organisations and national, European and regional authorities; assessment of impact and achievements at portfolio, programme and higher levels against the strategic objectives and indicators that are set within a clearly defined programme logic.

An independent **ex post programme evaluation** of FP7 would be undertaken within 2 years of its completion. This would be supported by the coherent set of independent studies, and other evaluation activities carried out over the life-time of the FP. The report of this exercise would be presented to all interested stakeholders, including the Parliament and Council. Furthermore, this report would feed into future ex ante evaluation and impact assessments by the Commission.

Furthermore, **ex-ante impact assessments** will be carried out at FP level and at the level of specific programme areas before the next FP proposal is made. The articulation between ex-ante impact assessment and ex-post evaluation will also be enhanced, as recommended by the Ormala Report of December 2004, in particular through ensuring the two exercises are timed to feed into each other. Ex-post work will therefore be available in time for the impact assessment of future policy options, and, in turn, the new policy objectives and performance indicators will feed into later ex-post work (Annex 1, Chapter 6, Section 3).

11. Stakeholder consultation

Throughout the history of the FP, great importance has been attached to consulting stakeholders in order to improve implementation and help in the design of the next FP. Indeed, the preparation of the FP7 proposal benefited from extensive inputs from the scientific community, industry and other interested parties making also use of new opportunities to organise online consultations through the internet. Various stakeholder consultations were launched by the Commission in 2004, based on the communication “Guidelines for future European policy to support research”. The most prominent message resulting from these consultations and supported by a broad consensus across different types of stakeholders: support for research at the European level should be strengthened and that all the Commission’s orientations – in particular in the fields of human resources, collaborative research, involvement of SMEs, realising the potential of an enlarged EU, identifying topics of major European interest – deserve the highest degree of backing. Reactions from the decision-making institutions EP and Council also support in a large part these orientations (Annex 1, Chapter 4, Section 3).

Table 2: Results of the stakeholders' consultation*

Six objectives proposed in COM(2004)353	% of respondents who consider objective to be important or very important	% of respondents who agree or mostly agree with the text in the Communication	% of respondents who consider the specified impact will be substantially greater or greater	Type of impact specified (compared to the current situation)
Collaborative research	90.8	88.9	84.5	Overall impact on the quality of European research
European technology initiatives	86	82.8	79.4	Overall impact on the quality of applied research
Basic research	81.2	78.6	75.2	Overall impact on the output of basic research
Human resources	96.1	92.3	92.1	Overall impact on European scientific careers
Developing research infrastructures	85.8	82.6	81	Overall impact on the performance of research infrastructures (developed through the use of trans-European networks)
Coordination of national programmes	84.5	82.9	80.3	Overall impact on the efficiency of the overall EU research system

***** 1727 responses were received to the online consultation based on the communication "Guidelines for future European policy to support research" (COM(2004) 353).

12. Conclusion: the Commission proposal and its justification

The final policy choice therefore consists of a substantially larger and excellence-based Framework Programme, which is organised around People, Ideas, Cooperation and Capacities, as outlined above. This choice has been made because all evidence shows that through this option the largest impacts would be achieved in terms of contributing to the achievement of economic, social, environmental and European Research Area objectives. This evidence has been drawn from a wide range of sources: inputs from stakeholders; technical and evaluation studies by European Commission services and the Commission statistical agency, EU-25 Member States and international organisations (OECD, IMF, UN organisations, etc.); inputs provided by recognised European experts in the fields of evaluation and impact assessment.

Although users sometimes complain about bureaucracy and administrative requirements related to their participation in RTD projects funded under the FP, efforts have been made to simplify and rationalise already the processes under FP6. Further special actions have been planned to facilitate participation by, for instance, SMEs and applicants from the new Member States. An enhanced monitoring system will allow for the rapid identification of adverse effects should they arise. To maximise positive impacts, special care has been taken to restrict the FP to actions with a clear European value added and monitoring and evaluation have been improved.

The "do-nothing" option (or indeed the down-sizing of EU intervention) is clearly ruled out as an option. It would stop in its tracks the process of building an integrated European Research Area, and would lead to greater fragmentation and inefficiency of research efforts in Europe. Research teams would carry out far fewer projects on a European scale, and would become more dependent on the resources and knowledge available in their own country. Reduced cooperation would have a weakening effect on the transfer of knowledge in the EU. Some important fields of S&T would therefore advance more slowly, while some countries may find that their capabilities in particular research fields are declining due to inadequate interaction with top teams located elsewhere. In terms of the coordination of national programmes, Europe would return to the complete fragmentation of the pre-ERA period, with 25 Member States and numerous regions defining their research priorities independently from each other and from the EU. The necessity for EU intervention in research is therefore not in question. All stakeholders consulted during the preparation of FP7 were of the view that the FP should be retained as a vital instrument of EU policy for the knowledge-based economy.

The “business as usual” option involves continuing with the FP as it is currently under FP6, with no change to its budget, structure or thematic content. While this option would provide continuity, it would not represent an adequate response to the new challenges facing Europe and the need to introduce improvements in the functioning and orientation of the FP. The Barroso Commission has placed renewed emphasis on the Lisbon objectives. Europe continues to lag behind other world regions in terms of economic and productivity growth and employment creation. While FP6 was devised as an instrument to implement the ERA and has made a positive contribution, to continue with the same FP structure and level of funding would not allow Europe to make sufficiently rapid progress towards the Lisbon goals. The EU now has 25 Member States. Keeping the same budget as for FP6 would result in a greater scattering of EU research effort, which must now be distributed between 25 not 15. It is clear that EU coordinating actions for research will need to grow, and that the FP must be expanded and redesigned to take account of the changing structure of the Union. Outside Europe too the world is changing. Emerging countries such as China and India are beginning to establish themselves as serious global players, and, if anything, competition in world markets is growing. The production and exploitation of knowledge must be at the centre of Europe’s strategy to compete in higher value products and services, rather than on the basis of cheap labour, and thus to be able to ensure balanced and sustainable growth. The next FP must respond to these challenges; business as usual will not suffice.

For the above reasons, it is vital for the FP to respond creatively to new dynamics and new needs, and to reinforce the contribution of EU research actions to the Lisbon strategy.

Table 3 - Expected impacts of the new FP7 and the do nothing option (business as usual scenario taken as a reference)

IMPACTS		POLICY OPTIONS	
		"do nothing"	**"new FP7"**
Expected aggregate impacts on the achievement of the Lisbon, Barcelona and other community objectives	**LISBON OBJECTIVES**		
	Economic growth performance	In the long run, up to 0.84 percent of GDP lost compared to the business-as-usual scenario	In the long run, between 0.45 and 0.96 percent **extra GDP** is generated compared to the business-as-usual scenario, because of **crowding-in** and **rates of return/multiplier effects**. The literature shows that the crowding-in effect of €1 of public R&D funding allocated to business has been estimated to range between €0.7 and € 0.93. The private rates of return to private R&D can be as high as 43 percent, the social ones as high as 160 percent. The rates of return to publicly-funded research could be as high as 67 percent.
	Employment creation	In the long run, up to 800,000 jobs lost compared to the business-as-usual scenario	In the long run, between 400,000 and 925,000 **extra jobs** are created compared to the business-as-usual scenario. The literature shows that the rate of growth of **total factor productivity** (TFP - due to improvements in the efficiency of production or to pure technological progress) has a positive impact on the **employment rate**, with a one-year lag, and that both in the short- and long-term, countries with higher than average TFP growth tend also to have higher than average growth in employment.
	Competitiveness	In the long run, extra-European exports lower by up to 2 percent, imports higher by up to 1.43 percent compared to the business-as-usual scenario	In the long run, extra-European **exports** could be higher by between 0.64 and 1.57 percent; **imports** lower by between 0.3 and 0.9 percent compared to the business-as-usual scenario. The literature shows that publicly funded research is critical for the development of new products, processes and services. Increases in R&D also increase productivity.
	BARCELONA OBJECTIVES		
	R&D intensity	In the long run, Europe's R&D intensity lower by up to 0.1 percent of GDP compared to the business-as-usual scenario	In the long run, Europe's R&D intensity higher by between 0.059 and 0.23 percent of GDP compared to the business-as-usual scenario. This is because of high crowding-in effects (see above under economic growth performance)
	Research employment	In the long run, up to 87,000 jobs lost compared to the business-as-usual scenario	In the long run, between 40,000 and 215,000 extra jobs compared to the business-as-usual scenario.
	OTHER COMMUNITY POLICIES		
	Göteborg strategy	Less informed design of EU Sustainable Development Strategy and disorganised consideration of the three pillars of sustainability	Knowledge-based design of the EU Sustainable Development Strategy and more balanced consideration of the three pillars of sustainability in the decision-making process; EU evidence-based leadership in international negotiations
	Other Community Policies	More ad hoc and inefficient development of perhaps less effective Community policies	Easier development of more evidence-based and effective policies in the fields of agriculture, economic and financial affairs, employment, enterprises, environment, fisheries, food, health, maritime affairs, etc.
	SPECIFIC PROGRAMME: PEOPLE		
	People	Less European mobility and cooperation; less attractive scientific careers for European citizens (in particular women); Europe less attractive to the best foreign researchers; reduced level and diversity of skills of individual researchers; less sustainable linkages between academia and industry, and across disciplines	More research can be carried out in Europe; research will generally be of higher quality, more inter-disciplinary, and where appropriate take industry better into account

	SPECIFIC PROGRAMME: IDEAS		
Expected impacts of Specific Programmes	**Ideas**	More national, non-competitive and overlapping funding; fewer scientific publications; publications of lower quality and fewer citations as the competition for basic research funding between individual research teams remains organised at national level, i.e. essentially meaningless in highly specialised fields of science in most countries	A better and enlarged knowledge base for European enterprises on which the innovation of products and process can be based; levelling-up effects as incentives are provided to increase institutional and researcher capabilities, produce better research proposals, and carry out higher-level research; structuring effects (dissemination; increased attractiveness ERA)
	SPECIFIC PROGRAMME: COOPERATION		
	Collaborative research	Greater fragmentation and inefficiency of research efforts in Europe; fewer projects carried out by research teams on a European scale and limited to resources and knowledge available at national level; more slow advance in important fields of science; in some countries, capabilities in particular research fields declining due to inadequate interaction with top teams located elsewhere	Some research activities are of such a scale that no single Member State can provide the necessary resources and expertise. In these cases, EU projects can allow research to achieve the required “critical mass”, while lowering commercial risk and producing a leverage effect on private investment. EU-scale actions also play an important role in transferring skills and knowledge across frontiers. This helps to foster excellence in research and development through enhancing capability, quality and EU-wide competition, as well as improving human capacity in S&T through training, mobility and European career development. EU support can also contribute to a better integration of European R&D, by encouraging the coordination of national policies, by the EU-wide dissemination of results, and by funding research for pan-European policy challenges.
	JTIs	Reduced competitiveness of European industries; reduced participation of industry in the FP; negative signal given to knowledge-intensive and high-tech industries	Important contribution made to the achievement of the Lisbon and Barcelona agenda through the formulation for areas critical for European competitiveness of ambitious, long-term and strategic research and wider policy agenda, the commitment of a critical mass of financial, organisational and human resources under public-private partnerships, indicatively sharing costs in a 1/3-2/3 format.
	International cooperation	Europe reneges on its commitments in international fora and goes entirely against the trend whereby other industrialised countries/regions are seeking to expand their international S&T cooperation.	Socio-economic development and global competitiveness stimulated; contributions made to Europe’s many key international commitments (e.g. Kyoto, Convention on Biological Diversity, Biosafety Protocol, the plan of Implementation adopted at the World Summit on Sustainable Development).
	Coordination of national research programmes	Return to the complete fragmentation of the pre-ERA period, with 25 MS and numerous regions defining their research priorities independently from each other and from the EU; waste of already scarce resources; opportunity lost to restructure the European research fabric so as to enhance EU competitiveness	Strong contribution made to the restructuring of the European research fabric in a coordinated and organised way and to the development of ERA.
	SPECIFIC PROGRAMME: CAPACITIES		
Expected impacts of Specific Programmes	**Research infrastructures; Research for the benefit of SMEs; Regions of knowledge; Research potential; Science in society; Specific activities of international cooperation** • **Realising full potential**	• Increased inefficiency and fragmentation of the European research landscape; less coordination of efforts, less possibility to share costs and access, potential duplication, loss of research capability • European SMEs deprived of important resources and opportunities to remain competitive in a global economy	• Better efficiency of public funds and stimulation of increased synergies between public and private funds; seamless access to all kinds of resources spread throughout Europe and the world. • The exploitation by SMEs of their research improved, EU-wide transfer of technology; research results potentially transformed into products and services
Expected impacts of management choices	**Administrative burden**	No administrative burden	Limited administrative burden; cost of participation reduced; procedures simplified and rationalised

COMMISSION STAFF WORKING PAPER

Annex 1: In-depth Analysis

IMPACT ASSESSMENT AND EX ANTE EVALUATION

For the proposals for the Council and European Parliament decisions on the 7th Framework Programme (EC and Euratom)

TABLE OF CONTENTS

Table of Contents

INTRODUCTION

This study presents in full the impact assessment of the Commission's proposals on the 7th Framework Programme (FP7) for Research and Technological Development (EC and EURATOM), the Specific Programmes and the Rules for Participation. The Impact Assessment Summary Report deals with the highlights of the Impact Assessment study. For more detailed information and explanations the reader is well advised to take a closer look at the study. Impact assessment is not new in the European Commission, however, since 2003, there is a new requirement that every legislative proposal of the European Commission should be accompanied by a report which assesses the expected impact of the measures in question on the economy, society and the environment.[1]

The seven key questions on Impact Assessment as outlined in the Secretariat General Guidelines have been taken as a starting point. In order to understand the rationale of the FP7 proposal, chapter 1 starts with a problem analysis of the role and impact of science and technology today and assesses Europe's 'research problem' in economic, social and environmental terms. Chapter 2 is instrumental in defining the policy objectives that will contribute to the solution of the problem. The issue of European added value is considered important in the area of European research policy and is described in detail in chapter 3. Before looking at the various policy options that could contribute to the objectives, chapter 4 looks at the impacts of previous established objectives as embodied in previous Framework Programmes. The results from the stakeholder consultation are also treated in this chapter. An assessment of the various policy options as well as their impacts defined in economic, social and environmental terms, are considered in chapter 5. This chapter concludes with the option that is considered the preferable available option providing the justification why this option contributes best to making Europe more competitive, more cohesive and more sustainable. Finally, chapter 6 assesses the positive and negative impacts of the policy options dealing with policy instruments, management modalities and monitoring and evaluation systems.

Although ambitious in its attempt, the study comes with a note of warning: assessing the impacts of research policy is difficult.[2] First of all, because it is difficult to establish a linear causal relationship between certain effects and a specific policy. Research and technological development unfold through complex, context-specific, social interactions and occur in unpredictable ways. It is also difficult, because of the time lag between doing research, generating innovations and reaping commercial benefits as well as the time lag in effects between different policy instruments and different policy actors. Difficulties in quantifying many predominantly qualitative effects such as increased networking, improved absorptive capacity, strengthened research competencies of firms, and changed behaviour add to the complexity. Notwithstanding these limitations, the study attempts to provide a comprehensive and coherent analysis of the expected impacts of FP7 compared with other policy options.

PART I: IMPACT OF S&T ON EUROPEAN CHALLENGES

One never notices what has been done; one can only see what remains to be done.

Marie Curie

Our time is one of high uncertainty. It is rich with threats and challenges as well as opportunities. The bipolar world has come and gone and with increasing globalization new trends are emerging: the supremacy of the United States, the rise or awakening of Asian giants, but also the persistence of underdevelopment and the growing inequalities between – and within – the nations of the world.

Throughout history, such phases of transition are associated with periods of transformation of the world economy and society, and generate new sources of competitive advantage, new international divisions of labour, new growth markets, new distributions of power and leadership, and new institutions of governance. Science and technology – together with education – are decisive factors in bringing about these structural transformations and in enabling societies to take advantage of them.

Against this backdrop, the first chapter of the report examines the contribution of science and technology to the challenges facing the European Union, with special emphasis on the role of S&T in contributing to the EU policy agenda set out at Lisbon, Barcelona and Göteborg. The chapter also addresses the importance of S&T in tackling problems at a its wider, global, level. For reasons of clarity, the impacts of science and technology are classified as economic, social, or environmental. However, it is important to recognize that some of these issues are cross-cutting in nature, particularly in the wider framework of sustainable development. In addition to the first three sections –relating to the impacts of S&T on the economy, the environment, and society – a fourth section surveys emerging trends in S&T. Further, if the chapter refers to "*the economy first, it is not because it is an end in its own right, but rather because a strong and dynamic economy is a pre-condition to our ambitious social and environmental goals*"[3].

The second chapter assesses the need for a reinforced European effort in science and technology, by analysing investment, performance, and the organization of the European research and innovation system itself. The third chapter examines the justification and efficacy of public intervention in science and technology – and looks in particular at the key issue of the added value of European level intervention in S&T.

Chapter 1: Challenges for science and technology set out at Lisbon, Göteborg and Barcelona

Europe needs more science and technology to become the most competitive knowledge based economy, for higher and sustainable economic growth and stability, to generate more and better jobs, for more social and regional cohesion, to satisfy the needs of the ageing society, to sustain a healthy environment, and to strive towards a better life for all. Indeed, if these momentous expectations are to be met, scientific and technological advances will have to provide us with the means to do so.

Section 1: Knowledge for growth, competitiveness and employment

Significant change has characterised the world economy over the past few decades. World trade has been liberalised as both formal and informal trade barriers have been reduced significantly, or disappeared altogether. Capital roams the planet freely in search of the best investment opportunities as barriers to capital mobility have been eliminated. Global communication and transportation networks have become denser and better integrated through a combination of technological and organisational innovation. The speed of technological change has accelerated while technologies are standardised more rapidly and use is made of modular production modes. As the combination of these factors has made it possible to locate the production of goods and services anywhere on the planet and still serve global markets, the global production system is in the process of being reconfigured.

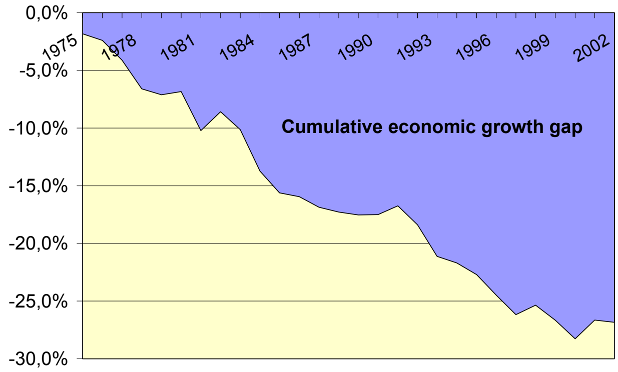
While the new international division of labour provides developing countries with ample opportunities, the blessing has been mixed for developed economies. On the one hand, low-, medium- and to an increasing extent high-technology manufacturing and services industries are under threat from delocalisation or so-called off-shoring and outsourcing, resulting in at least short-term disruption and unemployment. Employment is also under threat from rapid process innovation leading to productivity increases.

On the other hand, rapid product innovation provides developed countries with opportunities to improve competitiveness and serve global markets by fleeing forward as it were. The race to upgrade the economy is never-ending, however, and innovation-based advantages are fleeting and unsustainable as rapid standardisation and modular production techniques quickly allow the production process to move partially or completely to developing countries.

The need to boost European economic growth

Europe has not yet adapted to the rules of the new game, and is thus facing a number of challenges. For most of the last century, the European economy grew significantly faster than, or at least as fast as, the world economy[4]. However, in the second half of the post-war period, growth slowed significantly worldwide, but as shown in Figure 1 the decline was more pronounced in Europe than in the US, Japan and other OECD economies. In the last decade, Europe has done worse than the US, while Japan has once again started to outperform Europe, and the large BRIC (Brazil, Russia, India, China) economies and smaller East Asian economies continue to grow rapidly. It should be acknowledged, however, that some EU countries have performed rather well economically in the past decade. This group includes the Member States formerly classified as cohesion countries (especially Ireland), as well as Finland, the Netherlands and the UK.

Figure 1: Cumulative economic growth gap between the EU and the other industrialised countries (current prices and current PPPs)



Source: DG Research Data: OECD

Note: For both the EU-15 OECD countries and the non-EU-15 countries, 1974 GDP at current prices and current PPPs (billions of dollars) has been taken as 100. For all following years, GDP growth in percentages relative to the 1974 amount has been calculated. Then the series for the non-EU-15 OECD countries (Australia, Canada, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Switzerland, Turkey, US) has been set to 100 and the difference with the series for the EU-15 calculated.

Europe's economic future does not appear to look bright either, according to institutions like the International Monetary Fund (IMF) as well as the European Commission itself. While, at the Lisbon summit, 3 percent was agreed upon as a realistic target for EU average growth in the coming years, the IMF has recently revised downward the Euro zone's potential growth to about 2 percent[5]. Whenever Europe has been able to increase productivity it has suffered in the field of employment, and vice versa, pointing to the existence of structural barriers to growth[6]. According to European Commission projections, the economic impact of the ageing of the population could be to reduce the EU's potential growth rate from the current 2% to less than 1 percent by 2050[7]. In order to maintain current levels of industrial production and average per capita income with some 40 million elderly the EU would need to at least double the growth of productivity over the next few decades[8]. These economic and social challenges can only be met by investing in research and innovation, the key drivers of long-run economic growth according to modern economic growth theory.

The need to improve European competitiveness

The most common definition of competitiveness refers to the overall capacity to improve standards of living in a sustainable way.[9] By this standard, European competitiveness is clearly deteriorating. Europe caught up with the US during the 1950s and 1960s. But since the 1970s, European standards of living have been decreasing relative to the US. In 1970 euro-zone GDP per capita accounted for 70.1 percent of US GDP per capita. By 2000 this figure had dropped to 68.5 percent.[10]

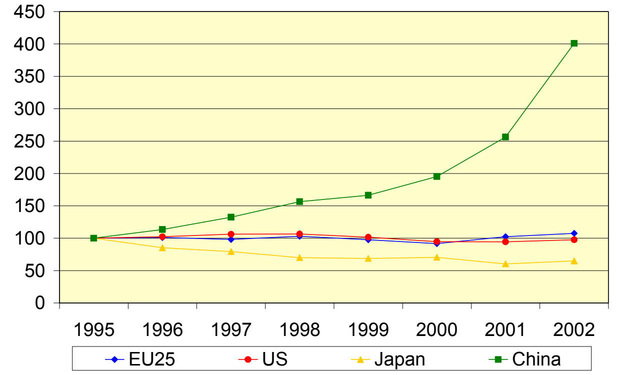
Labour productivity is another common measure of competitiveness. For most of the post-war period, on average the EU caught up with the US. But except for a few countries, the productivity gap was never closed, explaining about one third of the Europe-US GDP per capita gap. This catch-up has now stopped and is even being reversed. Since 1995, for the first time in three decades, growth in US labour productivity has outstripped that of the EU.[11] Furthermore, Europe has reached higher productivity to a large extent in a forced manner, by pushing low-skilled labour out of the labour market.

Deindustrialisation is often taken as a further sign of Europe's deteriorating competitiveness. The fear is that slow labour productivity growth, high labour costs, and short and inflexible working hours drive entire industries to low-cost, high-tech countries in Eastern Europe and Asia. Should it occur, deindustrialisation would indeed be worrying: the existence of many services depends on the presence of industry; industry pays better wages than services, even for low-skilled jobs; industry accounts for most innovations and technological revolutions; and industry has an important strategic role. But the evidence for deindustrialisation is not clear-cut. Some analyses point out that industry accounts for the same important share of GDP in terms of volume as in the past, while the declining share in terms of value added and employment is due simply to decreasing prices because of productivity gains and exposure to competition higher than that for services.[12] On the other hand, a recent American study found that off-shore R&D is expected to increase by 87 percent in the next three years.[13]

The relative strength of European industry has an immediate impact on its (high-tech) export performance, another common measure of competitiveness. High-tech trade competition continues to intensify as important new players enter the global market. China's economy in particular has grown very rapidly, and this has been accompanied by an equally dramatic rise in its high-tech exports, as shown in Figure 2. By 2002, it had already become the world's 6th largest exporter of high-tech products, which accounted for 21% of total Chinese exports.

As highlighted in the contributions from European industry during the stakeholders consultation on the future of European R&D policy, there is now a large consensus in Europe that industrial competitiveness can only be strengthened through creating value from new knowledge resulting from research and innovation.[14]

Figure 2: Growth in share of global high tech export market (1995=100)



Source: DG RTD, Eurostat Data: Eurostat Comext, UN Comtrade
Note: EU25 excludes intra-EU exports

The obligation to build a cohesive society

European employment input is lower than that in the US, and explains up to two thirds of the gap in living standards between Europe and the US[15]. While the share of the working age population in the total population is comparable to that of the US, the employment rate is much lower in Europe, mainly due to the limited participation of women, the young, and the elderly in the labour force. The Euro zone employment rate dropped from 95.2 percent of the US level in 1970 to 78.2 percent in 2000.[16] Europe also scores lower than the US in terms of the number of hours worked annually per employee, with Euro-zone levels falling from 101.2 percent of US levels in 1970 to 85.3 percent in 2000.[17] For a long time the decreases in the employment rate and the number of hours worked annually per employee were explained with reference to the European preference for leisure over work. But a growing number of authors draw attention to the existence of disincentives to work, the main one being the lack of employment opportunities. Industrial and technological specialisation is essential for the job creation capacity of the European economy as highlighted in an EU communication: "To combat unemployment, Europe must work to achieve stronger growth and target it on future-oriented industries".[18]

Declining fertility levels, in combination with ever increasing life expectancies, have led to an ageing society. Given the current structure of social security systems, the current average length of working careers, current levels of employment input, and current productivity levels, this will result in unsustainable dependency ratios and higher medical and pension costs. Therefore, in addition to the reform of social security and labour markets, there is an urgent need to create new employment opportunities and increase levels of productivity.

A final challenge to cohesion is posed by enlargement. Convergence does not happen automatically. It only occurs when certain key growth factors and supporting policies are present. The new

EU member states already have relatively high levels of human capital. But a decisive effort has to be made to overcome the aged industrial legacy and launch new higher-tech and higher value-added industries and services with the required growth potential.

The requirement to speed up the transition to the knowledge based economy

The Kok, Sapir, Strauss-Kahn and numerous other Commission as well as Member State reports have identified as the main problem for Europe its inability to make the transition to the knowledge based economy, and recommend the realisation of a knowledge society as the top priority.[19] The first policies in reaction to the slowdown in European economic growth were implemented in the late 1980s and early 1990s. They focused on the realisation of a fully open and integrated internal market for goods, services, people and capital; monetary integration and macro-economic stabilisation; and cohesion. They had important effects, but did not result in an improvement in Europe's economic performance.

The real problem is that the European system no longer delivers in today's world, which is characterised by economic globalisation and strong external competition. The European system is built around the assimilation of existing technologies and mass production which aims at economies of scale. Its industrial structure is dominated by large firms with stable markets and long term employment patterns. The European system should provide more opportunities for new entrants, greater mobility of employees within and across firms, more retraining, greater reliance on market financing, and higher investment in both R&D and (science) education at all levels. This requires a massive and urgent change in economic policies in Europe.

Knowledge for growth, competitiveness and a cohesive society

The recently proposed knowledge for growth pact, which puts research and FP7 at the centre, can help Europe to meet all four of the aforementioned challenges. The R&D policy of the Union is at the centre of the Lisbon strategy and the main tool to promote Europe's growth and competitiveness.[20]

Growth, competitiveness and employment are critically dependent on product and process innovation, which itself depends crucially on investment in research. The importance of investing in research is reflected in economic theory, through the neo-classical, endogenous and evolutionary models of economic growth. But there is also empirical support for its positive impacts (See Table 1).[21] Estimates of private returns to firms' own investment in R&D still produce varying figures, but there is an emerging consensus that gross returns between 20 and 30 percent are common and plausible. Microeconomic studies confirm the existence of significant spillovers of knowledge from the firms that perform the R&D to other firms and industries. Taking account of measured spillovers typically raises the estimated gross rate of return on business investment into the range of 30 to 40 percent.

Macroeconomic studies, which by definition cover all sectors of the economy, also find significantly higher returns to R&D in OECD countries, with estimates ranging from 50 percent to over 100 percent. At least two-thirds of per capita economic growth stem directly from technological innovation. A 1 percentage point increase in the R&D intensity of GDP would increase long term productivity growth by 0.6 percentage points. Growth accounting estimates show that ICT investment accounted for between 0.3 and 0.8 percentage point of GDP per capita growth over the 1995-2001 period. A recent Austrian report found that the rise of corporate spending on R&D from 0.8 percent to 1.1 percent of GDP in the second half of the 1990s produced a boost of three tenths of a percent in growth.[22] Both microeconomic and macroeconomic studies find that an important source of productivity growth in all OECD countries comes from the international diffusion of technology. A country's ability to absorb foreign technology is enhanced by investment in education and by investment in own R&D.

There are six main forms of economic benefit from basic research. It is a source of new useful information. Basic researchers create new instrumentation and methodologies. Those engaged in basic research develop skills which yield economic benefits when individuals move from basic research carrying codified and tacit knowledge. Through participation in basic research access is granted to networks of experts and information. Those trained in basic research may be good at solving complex technological problems, an ability of great benefit to industry. And on the basis of basic research, spin-off companies are created.[23]

The employment effects of investment in research and innovation are also positive. Clear evidence exists that more computerised or R&D-intensive industries increased their demand for college-educated workers at a faster rate in the 1980s. Such high-skilled workers command higher wages, as the consensus is that the increase in the schooling wage premium and the rise in wage inequality are driven by technological change.[24]

The economic literature is not conclusive on the employment effects of innovation, since process innovation (the introduction of labour-saving technologies) is likely to have a negative effect on employment, assuming all other factors remain constant, while product innovation creates new markets and employment opportunities.[25] But empirical evidence suggests that technological change promotes employment. Such evidence includes a recent DG Employment study which found that the rate of growth of total factor productivity (due to improvements in the efficiency of production or to pure technological progress) has a positive impact on the employment rate, with a one-year lag, and that both in the short- and long-term, countries with higher than average TFP growth tend also to have higher than average growth in employment.[26]

Table 1: Economic literature on returns to R&D

Private rate of return to private R&D

Author	Year	Private rate of return to private R&D
Terleckyj	1974	27 percent
Mansfield	1977	25 percent
Sherer	1982 1984	29-43 percent
Bernstein & Nadiri	1988	9-27 percent
Bernstein & Nadiri	1991	14-28 percent (6 manufacturing industries 1957-1986)
Lichtenberg & Siegel	1991	35 percent (Productivity growth for over 2000 US firms, 1972 to 1985)
Griliches	1992	27 percent
Nadiri	1993	20-30 percent
Hall	1996	Cluster around 10-15 percent, though can be as high as 30 percent in some studies

Social rate of return to private R&D

Author	Year	Social rate of return to private R&D
Terleckyj	1974	48-78 percent
Mansfield	1977	56 percent
Terleckyj	1980	107 percent (25 own plus 82 used R&D)
Sveikaukas	1981	17 percent (own R&D)
Sherer	1982	103 percent (29 percent own R&D plus 74 percent used R&D)
Sherer	1982 1984	64-147 percent
Griliches & Mairesse	1983	56 percent (406 Japanese firms, 1973-80)
Griliches and Lichtenberg	1984 a	34 percent (own R&D)
Griliches and Lichtenberg	1984 b	71 percent (30 percent own R&D plus 41 percent used R&D)
Odagiri and Iwata	1986	17 percent (135 Japanese firms, 1974-82)
Bernstein & Nadiri	1988	10-160 percent
Sassenou	1988	69 percent (394 Japanese firms, 1973-81)
Bernstein & Nadiri	1991	20-110 percent (Returns to R&D capital for 6 manufacturing industries in the USA over the period 1957-86)
Nadiri	1993	~40 percent
Griliches	1994	30 percent (own R&D)
Griffith, Redding & Van Reenen	2000	>40 percent (Inter-industry and international spillovers amongst 13 industries across 12 OECD countries,1970-92)

Rate of return to publicly-funded R&D

Author	Year	Rate of return to publicly-funded R&D
Griliches	1958	20-40 percent (Hybrid corn)
Peterson	1967	21-25 percent (Poultry)
Griliches	1968	35-40 percent (Agricultural research)
Evenson	1968	28-47 percent (Agricultural research)
Evenson	1979	45 percent (Agricultural research)
Davis	1979	37 percent (Agricultural research)
Schmitz-Seckler	1979	37-46 percent (Tomato harvester)
Davis and Peterson	1981	37 percent (Agricultural research)
Mansfield	1991	28 percent (All academic science research)
Huffman and Evenson	1993	43-67 percent (Agricultural research)
Nadiri & Mamuneas	**1994**	Up to 9 percent
Mamuneas & Nadiri	1996	Both publicly funded R&D carried out in the business sector and in the public sector generate statistically significant benefits. (Cost-reducing benefits of R&D stock in fifteen industries,1956-1988)
Toole	2000	1 percent increase in the stock of public basic research ultimately leads to 2-2.4 percent increase in the number of commercially available new compounds (Pharmaceuticals)
Cockburn and Henderson	2000	30 percent+ (Pharmaceuticals)
Tassey	2001	Rates of return on NIST infratechnologies match or exceed rates of return to private investment in technology

National returns to R&D

Author	Year	National return to domestic R&D
Frantzen	2000	Gross rate of return on domestic R&D: ~60 percent (OECD ,1961-91)
Bernstein & Nadiri	1991	Private and social marginal rates of return on investment in R&D: private: 21-28 percent; social: 21-86 percent
Coe & Helpman	1995	Marginal rate of social return: G7: 123 percent; smaller OECD countries: 85 percent (22 OECD countries,1971-90)
Lichtenberg & van Pottelsberghe	1996	Social rates of return on domestic R&D: G7: 51 percent; small EU countries: 63 percent
Guellec & van Pottelsberghe	2001	An increase of 1 percent in business R&D generates 0.13 percent in productivity growth; a 1 percent increase in foreign R&D generates 0.44 percent in productivity growth; a 1 percent more in public R&D generates 0.17 percent in productivity growth (16 OECD countries,1980-98)
Bassanini & Scarpetta	2001	0.1 percent increase in R&D intensity could lead to 1.2 percent higher output per capita; 0.1 percent increase in R&D intensity could boost output per capita growth by 0.3-0.4 (OECD countries over the period 1981-98)

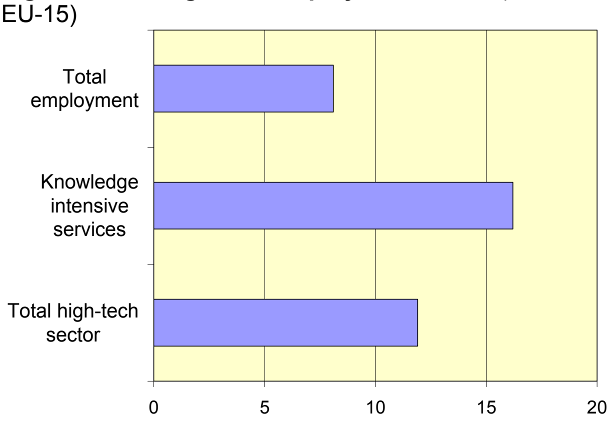
R&D and innovation

Author	Year	R&D and innovation
Adams	1990	Productivity growth depends on the accumulated stock of field-specific scientific research, operating with a twenty-year lag (18 US manufacturing industries,1953-83)
Mansfield	1991	11 percent of new products and 9 percent of new processes could not have been developed without a substantial delay in the absence of academic research (76 US firms in 7 industries)
Adams	1993	Basic scientific research provides fertile ground for applied commercial development (14 R&D-performing industries, 1961-86)
Acs, Audretsch & Feldman	1994	Own R&D activity is particularly important for large firms, whilst smaller firms tend to benefit from the knowledge created in publicly funded research.
Audretsch & Vivarelli	1996	Own R&D is important for large firms, whilst small firms benefit both from their own R&D and also from the presence of university-based scientific research activity in their region (15 regions of Italy, 1978-86)
Mansfield	1998	15 percent of new products and 11 percent of new processes could not have been developed without a substantial delay, in the absence of academic research.
Beise & Stahl	1999	One tenth of the firms which produced product or process innovations between1993-1995 would not have done so without public research. (2300 German firms in the manufacturing sector)
Autant-Bernard	2001	Public research increases private innovation directly and indirectly by increasing private research. These effects are geographically localised.
Tijssen	2001	Approximately 20 percent of private sector innovations are partially based on public sector research (Netherlands; nation-wide mail survey)

Countries benefit from foreign R&D

Author	Year	Countries benefit from foreign R&D
Benhabib & Spiegel	1994	According to the model technological progress is the sum of two components: an exogenous component, as in the neo-classical model; and a semi-endogenous component, related to the rate of absorption of technology from the technological leading country, captured by an interactive terms between the productivity gap and the level of human capital; the interactive term is statistically significant (Econometric estimation to explain variation in 20-year growth rates (1965-85) on a cross-section of 78 countries)
Coe & Helpman	1995	The average elasticity of domestic TFP with respect to foreign R&D capital is 0.09; it is higher for countries with high import ratios (21 OECD countries, plus Israel, 1970-90)
Lichtenberg & van Pottelsberghe	1998	Average elasticity of domestic TFP with respect to foreign R&D capital of 0.11; lower for low-trading countries
Griffith, Redding & Van Reenen	2000	High levels of domestic R&D and educational attainment stimulate the growth of TFP. Investment in both increase the capacity of industries to absorb technology from the overseas leaders (12 industries in 13 OECD countries since 1970)
Frantzen	2000	Confirms the benefits of education in technological absorption (Cross-section study of OECD countries)
Guellec & van Pottelsberghe	2001	An average elasticity of TFP with respect to foreign R&D capital of over 40 percent
Dowrick & Rogers	2002	The level of human capital facilitates technological catch-up, especially amongst the middle-income and richer countries

Figure 3: Changes in employment in % (1997-2002, EU-15)



Source: DG Research Data: European employment report 2003

Support also comes from the observation that all Member States except Luxembourg saw employment levels in the high technology sector rise between 1997 and 2002, leading to an increase of almost 2 million for the EU as a whole, with employment in high-tech services accounting for 1.4 million of this total.[27] Through its contribution to product and process innovation, productivity growth, and the creation of more and higher paid jobs, research and innovation can also help meet the challenges of ageing and cohesion.

Higher levels of employment and productivity will allow for the absorption of higher medical and pension costs. At the same time, product and process innovation, coupled with productivity growth, will enable the economically more advanced EU Member States to extend assistance to the new Member States, while allowing the latter to catch up more rapidly. More and better investment in research needs to be seen in a broader policy context. The Barcelona objectives for raising R&D spending have to be achieved, and a doubling of the FP7 budget will give an important signal to the EU Member States.

It is also clear, however, that more and better investment in research needs to be complemented with other, coherent and carefully designed macroeconomic and structural policies. Just as macroeconomic and monetary stability are considered necessary for long-term growth and industrial competitiveness, European growth and knowledge policies are essential if the positive effects of the stability pact on growth and employment are to be realized. Whilst respecting the objectives linked to the Gothenburg agenda, the commitment of the Kyoto agreement and key European policies, the coordination of different structural policies (R&D, education, competition, energy, environment, internal market, transport, etc.) must also be strengthened in line with the Lisbon objectives.[28] Unless macroeconomic and structural policies – both at Community and national level – can be coordinated in this sense, it will not be possible to achieve the main objective of Lisbon: for Europe to become a dynamic and competitive knowledge based economy in the next decade.

Section 2: Knowledge for sustainable development

A healthy environment is essential to long term prosperity and quality of life. In Europe, citizens demand a high level of environmental protection. Internationally, Europe has played a pioneering role in the environmental field, for example in the fight against global warming. A healthy environment is also a pre-requisite to achieve the Lisbon objectives, notably in relation to the EU Sustainable Development Strategy.[29] At the same time, high environmental standards are an engine for innovation and business opportunities, which are both at the heart of Lisbon. Furthermore, Europe is a world leader in environmental technologies.

Yet one of the most worrying global challenges is posed by the deterioration of our environment. This takes different forms. Some are dramatic, while others are less obvious, though they may occur in the long term and possibly with irreversible consequences.

Tacking stock: what are the challenges?

Eight prominent threats for the global environment and sustained economic development can be identified from a meta-analysis of recent forecasting studies.[30] These are: climate change, water quality, biodiversity losses, agriculture production, soil degradation, over-fishing, deforestation and air pollution. Furthermore, those are closely interrelated as, for example, forests and oceans act as climate regulators and harbour a wide diversity of species. The capacity to gather, interpret and use data on the state of the global environment forms a pre-requisite for engaging in environmental governance.[31]

Causes and strategies

The main causes found for these threats are population growth and consumption patterns; market, policy or political failure; nature of technology and finally cultural aspects, world views and values.

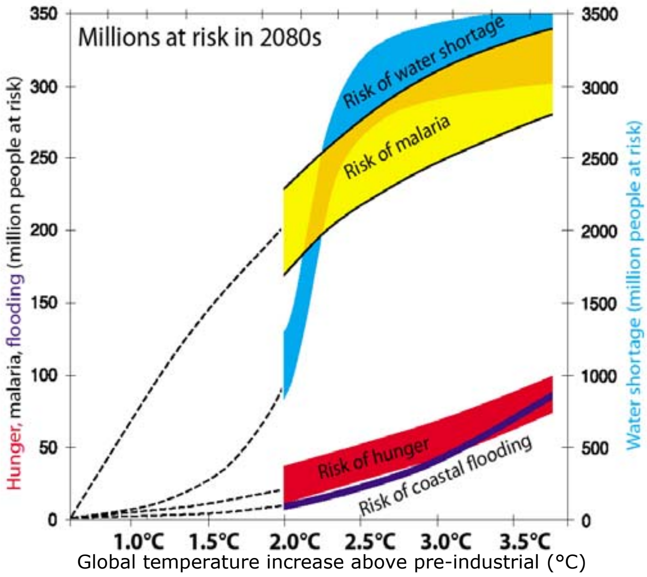
Some strategies are identified as a possible contribution to solve these threats. Among them one finds: encouraging sustainable consumption, creating and sharing knowledge, and catalyzing an environmental revolution in technology.

Europe faced with global threats: the case of climate change

We are thus confronted with global challenges that will require Europe to take a firm position and role, including in the field of research. Climate change forecasts indicate that if the level of emissions is not curbed, the temperature level will rise and risks such as water shortage, malaria and hunger will increase and affect millions of people by 2080 (see Figure 4).

Evidence of global warming has been recently provided by indicators on Arctic ice melting: ice surface in the Arctic has decreased by 10% since 1980 and ice thickness in 1990 was 2 meter compared to 3 meters in 1960.[32] Moreover, there is now strong evidence that most of the warming observed over the last 50 years is attributable to human activities. Different areas are sensitive to climate change, for instance agriculture, forestry, water availability, marine systems, terrestrial ecosystems, health and, last but not least, the economy. In order to prevent severe damage to the environment and society, and to ensure sustainable development even under changing climate conditions, not only mitigation, but also adaptation strategies and technologies are required – notably in the domains of energy and transport – while research is needed to provide the knowledge base.

Figure 4: People at risks from global warming in 2080



Source: Perry et al. (2001)

Further challenges, local and global

Biodiversity loss is ongoing at unprecedented rate. This was recently highlighted in the Commission communication "2004 Environmental Policy Review" (COM(2005)17). The planet's natural resources, such as clean water, soil, air, timber, fish and minerals are rapidly being exhausted as a result of population growth and economic development.[33] Waste management is another problem with environmental consequences for all societies. Waste can take up valuable land space and pollute the air and soil. The challenge ahead resides in the development and treatment of data and methods for understanding and predicting trends regarding natural resources, biodiversity and waste as well as the development of related management tools.

Environmental pollution also causes a range of human health problems, from allergies and infertility to cancer and premature death. In the mid-nineties damage costs (to the EU) caused by air pollution originated in the Union were calculated to be around 2% of the EU GDP, with health damages accounting for the largest share.[34] The communication "2004 Environmental Policy Review" (COM(2005)17) estimates that 2% - 8% of diseases in the EU-25 can be attributed to environmental factors, especially air and noise pollution from transport. New evidence has also been found on the health impacts of climate change, e.g. by heat waves, floods and climate variability influencing food and vector-borne diseases. This calls for additional research efforts in the field of environment and health.

Last but not least among environmental challenges are disasters. During the period 1990-1999 disasters killed 500,000 people and caused 750 billion dollars of damage, from issues including wildland fires, volcanoes, earthquakes, landslides, subsidence, floods, coastal hazards, tsunamis, ice hazards, extreme weather, and pollution events (also see Figure 7 in the next section). Research should contribute to putting in place prediction systems, observations and infrastructures.

Two indispensable pillars: political will and S&T advances

It is appropriate to acknowledge this grim evidence in the present Report, not least because S&T is an indispensable source for the evidence base on environmental change – and also because in some cases S&T is itself one of the causes of environmental degradations, for example, due to environmentally harmful production and consumption patterns. It is undoubtedly the lack of societal controls on the use of S&T that is at fault in this regard. However, the outlook can therefore change fundamentally if one can conceive of S&T as part of the solution rather than the problem.

The precautionary principle is a useful notion to mark that double perspective. It can first be taken as stifling innovation in the name of environmental protection; but more interestingly, it can be understood as promoting innovations that take account of social and environmental difficulties, taking account of risks as well as benefits, taking account of less tractable, longer-term consequences. Its emphasis – even with its origin in German environmental legislation in the 1970s – was as much on environmental protection as on gaining a competitive advantage through innovations on the backdrop of environmental regulation. Indeed, although this remains a fiercely debated question, a recent survey of the literature[35] indicates that a transparent and non-discriminatory regulatory framework, coupled with high environmental standards, is an engine for innovation and business opportunities. This engine functions notably through the creation of lead markets.[36] The story of the catalytic converters provides a compelling example of such R&D-based win-win.

A first step in that perspective consists in acknowledging the need to sever the link between economic growth and environmental degradation. The endeavour of a duly responsible polity – with a concern for the quality of life of present and future generations – is then to optimise the effects of its economic activity, i.e. to minimise adverse externalities without sacrificing part of its material well-being or endangering economic growth.

A second step consists not in ignoring the above 'limits to growth' understanding, but in researching other links between development and sustainability. This move is at the heart of the role of S&T in relation to the environment – and is indeed at the heart of the Lisbon Strategy as underscored in the Conclusions of the 2001 Göteborg Summit. The potential of technology to create synergies between environmental protection and economic growth was emphasised by the October 2003 European Council. That well-established premise is taken to its most fruitful operational conclusions in the Environmental Technologies Action Plan.[37] More recently, the benefits of S&T for the economy and environment alike were further examined in the '*Towards a more sustainable EU*' report for the Dutch Presidency and indeed in the Kok report of November 2004.[38] Of course this also relates to the fragile but powerful synergies, introduced above, between environmental promotion/protection, S&T, and growth and competitiveness.

These potential benefits can also be of great importance for developing countries. With appropriate technology transfer they can provide these countries with affordable solutions for reconciling their desire for strong economic growth with the need to do so without increasing the pressure on the local – or the global – environment. This North-South dimension highlights the sustainable development predicament as differentiated yet common. The question of sustainable development can be posed along two main lines: a question of adapting – or otherwise innovating – appropriate 'clean' technologies, and a question of redefining needs and lifestyles.

Now it is interesting to re-consider the climate change issue in the light of the above remarks. The European Union has taken a leading role in the international process to tackle global warming so as to promote environmentally responsible choices by all actors. The EU has ratified the Kyoto Protocol early on, joined by almost all of its international counterparts on this course – most recently Russia. Its successes are also the planet's successes. The EU is committed to meet its Kyoto emissions reduction targets[39] and continues to show leadership on this issue. The role of S&T is set to become even more central in the post-Kyoto (post-2012) regime, for which negotiations are starting now. The need for new and cleaner technologies as an indispensable means to tackle energy demands and CO_2 emissions was the main message of the latest yearly report of the International Energy Agency.[40] More widely, S&T play an important part in the EU's capacity to shape – and implement – international agreements.

By way of conclusion, it is worthy of note that the answers which science and technology can bring to environmental problems are increasingly judged with reference to the changes they bring in society. They demand choices of policies and governance, the impact of which on economic and social groups must be measured in terms of efficiency, the spread of costs and benefits, and social or regional equity. This is only possible if research also seeks to develop the knowledge-base and methodologies needed by such analyses.

Section 3: Knowledge for social welfare

Investment in S&T does not just contribute to a society's economic wealth. It also helps to improve the quality of life which can be understood as 'social wealth' in a broader sense. Such a conception is in line with Aristotle who defines "*wealth…not [as] the good we are seeking, for it is merely useful for the sake of something else*". According to the UN this "*something else*" is 'human development', defined by three dimensions: a decent standard of living; a long life in good health; and access to knowledge through education. These dimensions serve to structure the following analysis of the impact of S&T on our society,[41] which is followed by a forward-looking analysis underscoring modern vulnerabilities and the role of S&T in the emerging knowledge society.

Fighting poverty with S&T

Despite its high standard of living, poverty does exist in the Union, notably in the new Member States. In 2001, 15% of the EU population (approximately 56 million people) were at risk of poverty.[42] Numerous studies have illustrated the close connection between poverty and a lack of education.[43] As countries around the world serve to illustrate, the higher the illiteracy rate, the lower the income.[44] Education gives people access to resources that will enable them to enjoy a decent standard of living. Being educated enhances the chances of finding work. However, access to education is not open to everyone, but often only to those who can afford it. Education is, therefore, in its own right not powerful enough to solve the poverty problem. S&T is decisively needed as well. S&T can help to improve the productivity of natural and physical assets, for example, by protecting farmland against erosion and desertification, preserving an area's natural resources, building easy-to-maintain water storage facilities and de-salinisation installations, and strengthening farmers' diagnostic capabilities in relation to livestock diseases, to name a few.[45] That these advances have important impacts on farmers' income levels has been repeatedly demonstrated by the different targeted activities across the FPs.[46]

Also in the developed world, directing S&T investment at improving the returns to a society's assets are needed to combat poverty in order to provide real relief. Besides investing in education and developing skills, this means dedicating research programmes to find ways to fight inner-city poverty, to relieve the effects of urbanisation, to diminish the impacts of ever increasing mobility on our environment, and to improve the quality of life of the vulnerable groups in society, such as the handicapped and the ill, the elderly and the young.

One of the most inspiring examples of scientific progress having an impact on society is the dramatic reduction of infant mortality. The history of Europe is living proof of the importance of research resulting in breakthrough discoveries by dedicated scientists such as Semmelweiss, Lister and Pasteur. Infant mortality still exists, and its pervasive effects on a society's future have to be countered: one child in 6 born in the least developed countries dies before the age of five, compared to one child in 167 born in rich countries.[47] Further research is needed to reduce incidence rates and improve living conditions.

Improving human health with S&T

Reduction of poverty by improving health conditions has for a long time been one of the commitments of the EU.[48] The recent EU initiative in the research field to combat the poverty related diseases AIDS, malaria and tuberculosis constitutes a first coherent strategy in this sense - covering the whole development process for vaccines and drugs[49].

However, investing in health research is not only an act of solidarity to the poor regions. It directly affects the safety all of us, whether we are European citizens or not. Factors such as high mobility of people and goods, centralized food handling and climate change contribute to an increased global vulnerability (see below). This is manifested in outbreaks and rapid spread of infectious diseases across all continents and regardless of income levels. 30 new epidemics have been observed in the last 20 years, and more emerging or re-emerging diseases (resulting from antimicrobial resistance) are expected. SARS is considered as the first epidemic at global level of the 21st century. Statistics globally count 37.8 million of HIV infected persons[50]. Epidemics like AIDS are advancing unchecked in Eastern Europe and Asia[51]. The bird-flu outbreak in 1997 was the first of direct avian-to-human transmission of influenza.

Unpredicted research actions - such as the FP6 initiative of € 15 million into research on SARS - need to be possible in order to respond immediately to such threats. Research into influenza prevention is particularly pertinent for the EU, since five vaccine manufacturers representing 70% of the worldwide production of human influenza vaccines are located in the EU, thereby making them global suppliers through export.

The help S&T provides through the development of remedies to diseases is also dependant on an efficient public health policy and system. Apart from that, S&T can also contribute to reduce the direct (health care) and indirect (inactivity and loss to the economy) costs of disease. Advances in the management of major diseases such as cardiovascular, neurological and psychiatric diseases, cancer and diabetes have enormous impact on human well being as well as on the economic costs of illnesses. Research in health does represent an economic challenge, notably for the industrialised countries aiming at containing their health costs. This is relevant for most of the EU Member States, which face an alarming acceleration of their health expenditures[52]. Take the example of demographic change. Advances in medicine, improved healthcare monitoring, better personal hygiene, better geriatric care and more health conscientious behaviour, to name few, have all had favourable effects on people growing older. This offers wide opportunities, but also involves societal challenges. The extension of working life impacts both on the employment and pension systems.

A particular demand is put on the health systems when it comes to providing care and tackling chronic conditions of ageing such as dementia, cardiovascular disease etc. In addition, ageing has a dramatic impact on care costs. On the one hand, costs increase with more people growing old and needing care. On the other hand, the UK National Audit Office has indicated that a 1% improvement in autonomy would result in a £17 billion annual reduction in health care costs[53]. There are many areas where social, organisational and technological innovation might significantly alleviate the effects of population change by promoting active ageing.

The mutual shaping of culture and S&T

The examples in this section show how profoundly our culture is marked by S&T developments. At the same time as S&T shape our society, they are themselves produced, taken up, reconfigured, shaped by society. That is one (double) way in which culture is decidedly scientific culture. But to allow all sections of society to benefit from those advances – as well as to take part in that shaping process – individuals need to be provided with the appropriate equipment, in terms of education, skills, awareness, and appreciation for the stakes in S&T endeavours. Vital for a democratic society, such demands point towards another crucial sense for scientific culture, also exposing the acute need for it to be developed. Actions to foster a thorough public grasp of what is science and how it contributes to society are thus *sine qua non* to a full-fledged democratic society.

Importantly, S&T developments accompany and affect lifestyle changes in societies. In this respect the taking up of GSM phones provides interesting illustrations[54]. The GSM has strikingly changed the way people communicate with their loved ones, organize their work and outings, and live everyday. As regards research, innovation, and competitiveness, the rise of the GSM standard provides an inspiring example of European leadership. The information and communication technologies open up opportunities for new lifestyles and new ways of working[55]. Working remotely or online trading decouples economic activity from a particular geographic location (be it the office, capital cities or structurally favoured regions). Moreover, such technologies can facilitate access to employment – and other forms of social inclusion/participation[56] – among sections of society (people with physical disabilities, the elderly) who may otherwise be excluded. Key to achieving those benefits is ensuring that people are equipped with the necessary skills to get involved. Much information society literature[57] also hypothesises that 'eWork' (remote working) may contribute to environmental sustainability as, in addition to other dematerialisations, travelling to work is reduced. On the other hand, transport technologies themselves – from the wheel through to the airplane – continue to have a central role in society, e.g. in enabling communication.

The quality of human life is made up of many more components than the ones already mentioned: greater access to knowledge, better nutrition and health services, more secure livelihoods, clean air to breathe, security against crime and physical violence, satisfying leisure hours, political and cultural freedoms and sense of participation in community activities. S&T can contribute to improvements and bring lasting solutions in each of these areas. For example, investment in research and new technologies to achieve sustainable transport solutions generates desirable impacts on the quality of life worldwide: less energy consumption; fewer air pollution; less respiratory diseases; lower noise levels; increased space and security for pedestrians and cyclists resulting in more friendly cities for children and older people; less congestion; fewer road accidents; etc. Besides, it is S&T which makes possible the novel lifestyles – and indeed the novel society – discussed above.

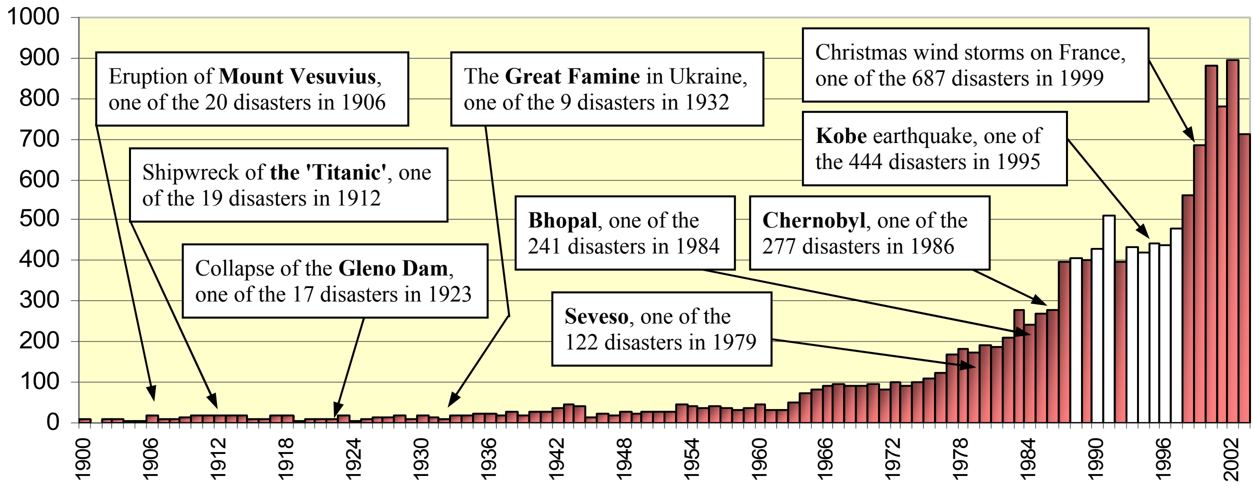
It may be that, in solving some age-old problems, S&T has created the possibility for new problems to emerge. Yet even to address these new problems we cannot do without S&T. But we can – and rightfully do – concern ourselves with the consequences of the solutions we devise.

The vulnerable society and the knowledge society

S&T has brought a mix of benefits and risks. In the modern world heightened wellbeing and security are accompanied by increased vulnerability and insecurity. This vulnerability can take many forms, from loneliness or travelling accidents to industrial disasters or the twisting of human rights in a totalitarian state.

For example, Figure 5 provides an illustration of the rising challenge represented by disasters. Here 'disasters' include both technological and natural events. For a disaster to be entered into the database and thus shown on the figure, at least one of the following criteria must be fulfilled: 10 or more people reported killed; 100 people reported affected; declaration of a state of emergency; call for international assistance.

Figure 5: Total of disasters reported (1900 – 2003)



Source: DG Research

Data: EM-DAT (The OFDA/CRED International Disaster Database)

The dramatic increase shown on the graph may be due not only to the consequences of concentrated urbanisation, climate change, etc, but also to a heightened sense of vulnerability and risk, together with a better ability to measure disasters.

Hence the emerging knowledge society will have its problems too. Besides, it will not depend solely on S&T but also on governance and on the citizens who will make up our society – and shape it. Yet it is characterized by an increasingly pivotal role for S&T. The knowledge society requires a revolution in our understanding of knowledge: not only with regard to S&T researchers, but also concerning a democratisation or broadening of knowledge production. This has profound implication for decision making, for the lay-expert divide, for the handling of risks and uncertainties, and indeed for the relations between citizens and institutions of governance, as every individual should be recognized as – and given the means to be – a person of knowledge.

Section 4: Knowledge, the endless frontier

The three previous sections in this chapter have illustrated how science is an activity undertaken out of utilitarian motives, whereby economic crisis, real life disorders, diseases, and disasters have been the spark to light the quest for new knowledge. Yet, science is also undertaken for science's sake, out of scientific curiosity without a clear 'end product' in mind.

When in 1899 Charles H. Duell, Commissioner at the U.S. Office of Patents, allegedly claimed that "*everything that can be invented has been invented*", little did he know that his quote would end up as one of the most infamous quotes of modern times. The progress in computer technology is the example par excellence to demonstrate how endless the knowledge frontier apparently is. In a time when computers had the size of machine engines rooms, little evidence was there to prove Thomas Watson, chairman of IBM, wrong when he estimated in 1943 that "*there is a world market for maybe five computers*". Also Ken Olson, president, chairman and founder of Digital Equipment Corp., demonstrated in hindsight the limits of foresight, when he proclaimed in 1977 that "*there is no reason anyone would want a computer in their home*". In 2003, almost half of all European households (44%) had access to the internet at home. Apparently, there is something about human nature that challenges very technological frontier as soon as it is established.

New S&T developments create new opportunities to achieve the Lisbon agenda

The contribution that emerging science and technology can make to achieving Europe's ambitious goals for the knowledge society should not be underestimated. A European approach is needed that places curiosity-driven research high on the political agenda.

To give an example, new developments in ICT are likely to extend even further our ability to store, process and interpret information, to communicate, to visualize and to control beyond any natural human ability[58]. This rapid scientific and technological change is not exclusive to ICT. New developments can be witnessed at the intersection of all research domains. Foresight research work carried out for the European Commission predicts that a new technology wave centered around "nano-bio-info-cogno convergence" will create new functionalities with a capability to intrusively re-shape society[59].

This new technological wave also makes the demarcation of research into 'basic', 'applied' and 'technological development' components more blurred. Science and technology are becoming far more closely intertwined than previously. Today, this is already reflected in universities' increasing involvement in the application and even exploitation of scientific knowledge. The 1980 Bayh-Dole Act achieved a major breakthrough enabling universities and public research institutes in the US to commercialise their scientific output. This accelerated the creation of university spin-offs and new technology-based firms by entrepreneurial scientists who combined scientific curiosity with commercial creativity.

Likewise, many companies (e.g. pharmaceutical multinationals, biotech start-ups) are becoming increasingly involved in basic research. That is why the European Commission has adopted a new term, 'Ideas' (frontier research), to capture the changing nature of research. Key to frontier research is the fact that it is basic and applied at the same time – i.e. the two are not necessarily mutually exclusive. More and more research is, hence, concerned both with seeking new knowledge about the world and with uncovering potentially useful knowledge.

As Susan Greenfield recently underlined in her Millennium Lecture:[60] "*The two great intellectual challenges for science in the new millennium are to understand the nature of ourselves (our genome, our minds, our consciousness) and the nature of the world in which we live (cosmology, - the history of how things came into being, and environment, - the here and now).*" Investing in curiosity-driven research is absolutely necessary in this respect. This includes social sciences research in order to help us understand the transformation dynamics of contemporary societies.

The new technology wave

The new technology wave consists of technologies that share five common characteristics:[61]

Convergent: the technologies are exploited in several ways and used for different applications in many areas. Fusion plasma diagnostics are applied in the semiconductor industry. Technology designed initially for the semiconductor industry, such as the scanning tunnelling microscope, can be used to observe genomic structures. Genetic and neural models have been adopted by researchers to develop learning systems. Data mining applications, developed for commercial research, are used to mine abstracts of pharmaceutical research. Faster, more powerful, computers and software enable the simulation of experiments, taking them "off the bench" and thereby permitting "experiments" that might otherwise be too costly or dangerous.

Fundamental: the technologies tinker with very fundamental processes. Biotechnology modifies life forms. Nanotechnology permits the direct manipulation of atomic structures to create previously unknown chemicals and materials, not to mention amazingly small devices. Information technology mimics, and in some cases surpasses, human intelligence.

Replicant: each of these technologies has some capability to "reproduce" itself. Modified life forms reproduce in the normal biological manner. Nano-devices are likely to duplicate themselves via nano-assembly. Computer code has the ability not only to duplicate itself but also to modify itself in a primitive (so far) learning process.

Distributed: all of these technologies can be used by individuals. Unlike the big, centralized industrial technologies of the 20th century these operate at a low, distributed level. This gives them both power and the possibility of misuse.

Public Interest: there is interest and concern in the general public over the use and misuse of these technologies. There is a sense that they will hold much promise, but at the same time be very disruptive which calls for a better explaining of their real risks and benefits to the public.

Besides change in the scientific disciplines towards "trans-disciplinarity", foresight studies point to the changing institutional modes of knowledge production. Multi-actor, multi-national partnerships, the interaction between science and citizens as an expression of democracy and the increase in transparency to report on the implications of research findings will all make a big difference from the way science was undertaken in the 19th and 20th century. Investing in curiosity-driven research has important impacts on our culture and our ability to exert our citizens' rights in complex democratic systems.

Revolutionary changes in the way scientific disciplines are interacting and converging lead to increasingly complex knowledge systems where technological and social elements interact. The implications of an ageing population, the transformation of healthcare, changing consumer behaviour, environmental threats and risks, the management of environmental resources and energy supply, are all examples of highly complex and systemic problem areas. They are complex not only for technical reasons, but also because they involve the interaction between science and society. To give an example, biotech advances can without doubt improve the quality of life, however, current debate about genetic engineering underlines the political importance of ethical and risk issues which demand further research and continued testing. Also property rights protection, whether it concerns new drugs to fights AIDS or more disease-resistant new crops, constitutes an area where care has to be taken to install a system that balances the interests of the inventors against the needs of the end-users such as sick people and poor farmers.

The future of European culture depends on its capacity to equip young people to question constantly and seek new answers without prejudicing human values. This is the very foundation of citizenship and is essential if European society is to be open, multicultural and democratic. In this regard, the most eminent academics stress the importance of adequate scientific awareness – not simply in the mathematical sense – to ensure that democracy can function properly.

Chapter 2: From analysing the problem to defining policy objectives

Europe sits upon many centuries of accumulation of knowledge. The Renaissance, for example, was also a renascence in terms of mobilisation, excitement, and investment (by states and church, cities and universities, entrepreneurs and philanthropists) in science and technology. Up until the beginning of the 20th century, the most fortunate Americans would send their children to study for PhDs in Europe. Europe was the centre. Then the tables slowly turned. Whereas Europe had long held the scientific and technological leadership, other countries and regional blocks emerged (first the US, later Japan, etc). Through the last century Europe underwent a gradual decline in that respect, for external reasons as well as internal reasons: two devastating wars, unmistakably, but also the appearance of other priorities, with other choices being made. It seemed that, although we still talked of investing in R&D, we were unable to take decisive action. The scientific and technological potential of Europe remains exceptional, in terms of universities, private ventures, research infrastructures, etc, and indeed in terms of individuals eager to learn (and impart, and use) knowledge and skills – and to make a difference in the world. That potential needs to be revitalized, so that science and technology can be placed at the centre once again.

This chapter considers the state of the European research and innovation system. The first section provides a quantitative analysis of Europe's investment in research, as well as its scientific, technological and economic performance. Comparative data are presented for its main competitors. The conclusion is that Europe needs to invest more in research to move towards a knowledge based economy. The second section goes on to explore a number of structural weaknesses in the EU which reduce the efficiency of its R&D investments and make it less attractive as a research area.

Section 1: Should Europe invest and perform more in R&D?

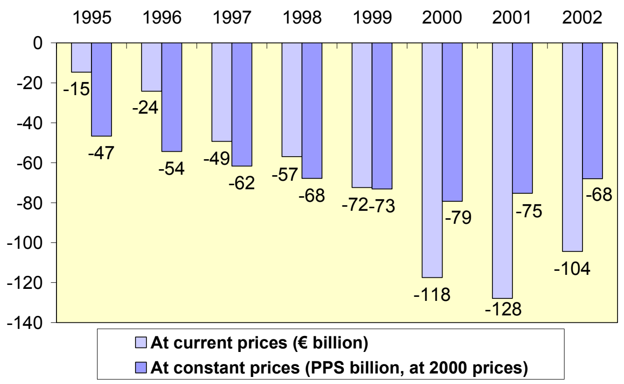
It has been shown in previous sections that Europe needs to invest in science and technology if it is to address the economic, social and environmental challenges it faces at the beginning of the 21st century. This section examines whether Europe’s current investment is adequate, and analyses how well this S&T effort is being transformed into innovation and competitiveness. Many of these issues have already been explored in various studies at national and international level[62], and this evidence base, discussed in section 1 of chapter 1, has been taken into account in the preparation of this section.

According to the recent EC study on "The costs of non-Lisbon", the US is investing roughly $ 200 billion more annually on its knowledge economy than the EU[63]. This important knowledge investment gap is due mainly to the European underinvestment in R&D as well as in education and innovation. Over the past decade, European public R&D investment has not increased sufficiently, even though competitors are rapidly increasing their R&D expenditure, new fields of science have emerged and the costs of carrying out R&D is rising fast.

R&D investment gap: Europe is still under-investing

The gap between the EU and the US in terms of investment in R&D has been the subject of much attention[64], and its significance is now widely accepted. In absolute terms, the EU spends significantly less than the US on R&D. Cumulatively, between 1991 and 2001, the US invested nearly € 600 billion more (in real terms)[65] than the EU. By 2001, the gap had reached € 128 billion, more than 60% higher in real terms than its level in 1995. However, latest data for 2002 show some reduction of the gap, although this would appear to owe more to the slow growth of US R&D since 2000 than to increases from the EU.

Figure 6: R&D investment gap between the EU-25 and the US (in billion € and PPS at 2000 prices)



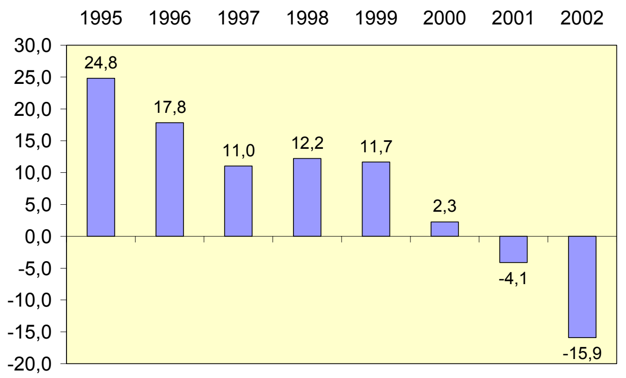
Source: DG Research, Eurostat Data: OECD, Eurostat
Notes: EU-25 estimated for 1995-98, 2000, 2002; Luxembourg and Malta are not included in the EU-25 total

But Europe's under-investment can no longer be seen as a purely transatlantic phenomenon, defined simply in relation to US R&D spending. A number of dynamic countries in the Far East, including China and a recovering Japan, have been gradually intensifying their efforts to invest in the knowledge-based economy. During the 1990s they were investing less than the EU in R&D, but the situation is now reversed (Figure 7).

Europe's under-investment is also reflected in the proportion of its GDP it invests in R&D. Since the second half of the 1990s, Europe has been seriously lagging behind other countries recording a level of approximately 2% for some years, compared with around 3% for the US. Latest data for 2002 still show the EU trailing the US (EU-25 1.96%, US 2.59%), while a number of Asian countries are either ahead of the EU (e.g. Japan at 3.12%, Korea at 2.91%) or have recorded dramatic increases in their R&D intensity since the mid-90s (China, Singapore).

Investigating the EU-US gap in more detail, it becomes apparent that about 80% of it is due to the difference in business R&D between the EU and the US. This is the reason for the target set by the European Council at the Barcelona summit for 2/3 of European R&D to be financed by industry by the year 2010. Military R&D is a second important factor explaining the R&D gap with the US. The gap between the EU-25 and the US in government spending on defence-related R&D was € 46 billion in 2002 (the US invests € 57 billion in defence, versus 11 billion by the EU)[66].

Figure 7: R&D investment gap between the EU-15 and selected five Asian economies[(1)] (In real terms – billion 2000 dollars, constant prices and PPP)



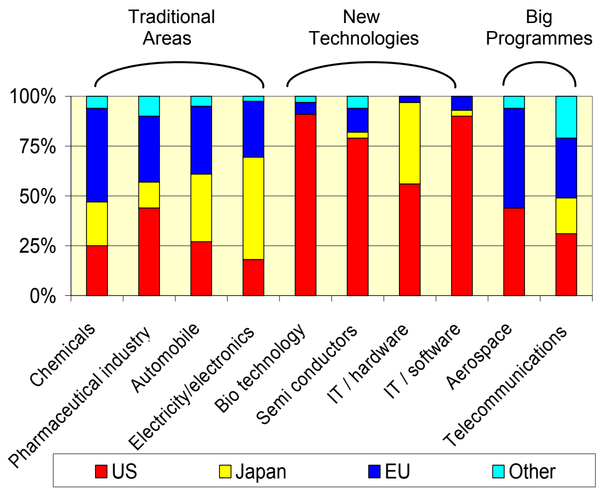
Source: DG Research, Eurostat Data: OECD, MSTI
Note: (1) Japan, South Korea, China, Taiwan, Singapore

The spending gap between Europe and US can be attributed in large part to differences in R&D spending by SMEs in the two regions. Higher R&D spending by European SMEs could therefore play a key role in helping to achieve the 3% Barcelona target.

In terms of sectors and S&T fields, Europe's R&D spending in the more "traditional" areas (e.g. chemicals, automobiles) compares favourably with that of its partners. However, it lags behind the US when it comes to investment in new technologies (Figure 8). In the field of ICT in particular, Europe spends far less on R&D than the US and Japan[67]. Europe also spends far less on defence-related and 'dual' research which in the past has proven to have important spin-offs especially in the ICT area. In Space, the US invests five times more than the EU. EU-15 has a public investment of about 0.06% of its GDP in Space activities against an investment of 0.30% of GDP in the US. The investment gap is considerable in other promising sectors as well. In nanotechnology the average level of public investment in 2003 for the EU-25 was € 2.4 per citizen (€ 2.9 for the EU-15), compared to € 3.7 for the USA and € 6.2 for Japan.

Looking ahead to the next ten years, America may find it difficult to reproduce its investment levels of the 1990s. The sizeable US budget deficit ($ 413 billion[68] – an estimated 3.6% of GDP for fiscal year 2004) may negatively affect public R&D financing and also give rise to higher interest rates, which would result in higher R&D financing costs for the private sector. In Europe, following the Barcelona summit, there is evidence of an enhanced resolve in most Member States to stop the decline in R&D spending, with several now setting national targets. One would therefore anticipate a slowing down or even reduction of the EU-US gap. On the other hand, it is the R&D gap in relation to the dynamic and emerging economies of Asia that will become a major cause for concern.

Figure 8: Europe's position in new technologies – Breakdown of R&D expenditures (%)



Source: Le Monde Data: OECD

The EU has too few researchers, despite being a major producer of S&T graduates

The EU will need more human resources in S&T to reach the 3% target for R&D intensity set at Barcelona. However, because of insufficient investment in the past, Europe has far fewer researchers in relation to its labour force than the US and Japan (EU-25: 5.3 per 1000, US: 9, Japan: 9.7). However, there is considerable variation between the Member States, with some (Finland, Sweden) boasting a higher proportion of researchers in their labour force than the US, while others (Cyprus, Italy, Czech Republic) have less than 3 per 1000.

However, the EU generates a large number of graduates and PhDs per year (2.9 million in 2001, versus 2.1 million in the US in 2000). Moreover, more than one quarter of them graduate in science and engineering disciplines (26.3% in EU-25, versus 17.2% in the US and 21.9% in Japan). The EU also produces more S&E doctorates per year in relative terms : 0.56 out of 1000 people aged 25-34 obtained an S&E PhD in the EU, 0.41 in the US and 0.25 in Japan. However, it needs to invest more to create the posts in laboratories, and to make employment in S&T more attractive, so that these graduates will pursue scientific careers, and do so in Europe. Creating more attractive conditions for foreign researchers to come and work in Europe will also help.

There is of course a huge resource pool that should no longer remain under-exploited: women scientists. It must be ensured that both girls and boys choose to study scientific subjects at school. And later, better use must be made of the significant numbers of women who then graduate in S&E disciplines, but who either fail to enter scientific careers, or find themselves stuck in the lower echelons of public and private research labs. Women are consistently under-represented as PhD graduates, as researchers – especially in the Business Enterprise Sector – among senior university staff and as members of scientific boards. Only a third of researchers in higher education and government research institutions are women, and only 15% of researchers in the business enterprise sector.

Unless steps are taken now to tackle these problems, a shortage of highly qualified S&T personnel in the next 10-15 years will pose a serious threat to the EU's innovative strength and productivity growth.

Knowledge production: Europe is excellent in science, but needs to invest more effectively to maintain its level

Europe leads the world in terms of the number of scientific publications. In 2002, the EU-15 accounted for 36.4 percent of the world's scientific publications, as compared to 31.4 percent for the US and 9.9 percent for Japan. If one looks at the number of publications per inhabitant, Europe comes second. In 2002, the number of scientific publications per million population amounted to 673 in the EU-15, as compared to 774 in the US and 550 in Japan.

The quality of European research is also good. This is reflected in the fact that as far as highly cited papers as a percentage of the total number of scientific publications are concerned, a substantial number of EU countries score above the world average. In terms of disciplines, the EU is on a par with the US in the physical sciences, engineering and mathematics, but lags in life sciences[69]. Europe is therefore in an essentially strong position, but to maintain this it will need to boost its levels of investment in basic research, and reduce the current fragmentation of its spending.

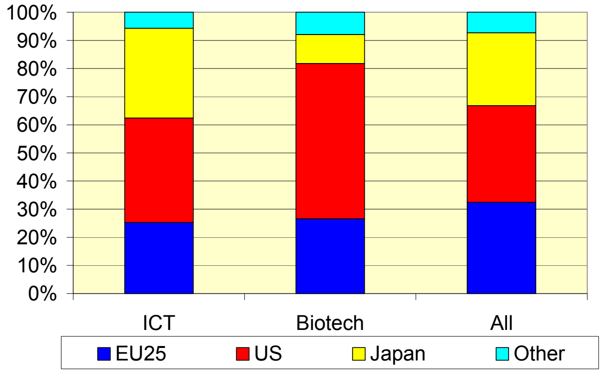
Inventiveness: Europe needs to do more to transform the results of research into commercially valuable innovations

While Europe plays a leading role in terms of its science and the provision of S&T graduates, it largely fails to convert science-based findings into commercially valuable innovations. In relation to its population, Europe generates fewer patents with high economic value than the US or Japan: in 2000 the EU-25 had 31 so-called Triadic patents[70] per million population, versus 53 for the US, and 93 for Japan. The EU's share of Triadic patents is also less than that of the US (31% versus 34% for the US).

The US also has a higher share of patent applications at the European Patent Office (27%)

than the EU has at the US Patent Office (16%)[71]. On a yearly basis, Taiwan makes more patent applications to the US Patent Office than either France or the UK. In key areas such as biotechnology and information and communications technologies, Europe also lags behind in its share of patents. In biotechnology, EU-25 accounts for only 27% of high-value "triadic" patents, compared with 55% for the US. In ICT the shares are 25% for the EU versus 37% for the US.

Figure 9: Shares of triadic patents (%)



Source: DG Research, Eurostat Data: OECD, Patent Database
Notes: (1) Triadic patents relate to those inventions for which a patent application is made in each of the three patent offices (EPO, USPO, and JPO). (2) Data are for the priority year 1998, by country of the inventor

Competitiveness: Europe needs to exploit its S&T better in order to improve its competitiveness, especially in terms of selling new products abroad

There is a broad consensus that the EU needs to takes urgent measures to increase its competitiveness if it is not to be overtaken by other rapidly growing economies. It is also widely accepted that one of the key objectives of such measures should be to move Europe faster towards a knowledge-based economy – the cornerstone of the Lisbon strategy.

The "Kok report" [72], reviewing Lisbon, makes it clear that progress has been too slow, and argues that, to respond to the challenges of Asia and the US, Europe must "develop its own area of specialisms, excellence and comparative advantage which inevitably must lie in a commitment to the knowledge economy in its widest sense". This view is increasingly shared by governments across Europe. The four EU-Presidency statements[73] made a commitment to getting Lisbon back on track in 2004-2005, and emphasized the key role played by research: "to increase the supply of state of the art research, knowledge and world class researchers, the EU should invest more in knowledge creation".

However, at the core of Europe's difficulties is the transfer of research to commercially successful innovation.[74] After a debate going back a number of years, there is a general consensus on what is referred to as the "European Paradox": that Europe has a strong research base, but fails to exploit this downstream when it comes to improving its competitiveness, developing new products and processes, and boosting productivity.[75]

As seen in chapter 1, Europe's performance in terms of labour productivity remains a cause for concern. The catch-up in terms of GDP per hour worked has stopped and since 1995 the gap is increasing again. While, on average, productivity growth was higher in the EU than in the US during the period 1979-1995, this situation was reversed in the period 1995-2001. The Lisbon review attributes much of this trend to a slowdown in the rate of technological progress in Europe due to "insufficient investment in R & D and education, an indifferent capacity to transform research into marketable products and processes, and the lower productivity performance in European ICT producing industries (including office equipment and semiconductors) and in European ICT-using services (such as wholesale and retail trade, financial services) due to a slower rate of ICT diffusion". It warns that Europe's poor performance is also linked to its industrial structure, which is based on more low- and medium-tech industries, and its difficulty in moving into those sectors with high productivity growth prospects.

These weaknesses can be seen when it comes to Europe's commercial exploitation of its S&T, especially if one examines its sales of cutting-edge products in international markets. In 2002, the EU25 was running a trade deficit in high tech products of 33.7 billion euros, much of this due to weaknesses in computers, electronics and telecommunications. Europe's performance in the export of pharmaceuticals is good, but this represents a much smaller volume of total trade.

High tech products form a much smaller proportion of Europe's total exports than is the case in the US and Japan (18% of EU-25 total trade in 2002 was high tech, compared with 25% in Japan and 29% in the US). Europe's share of the global high tech market was 19% in 2002, well below the 24% held by the US.

Europe's most dynamic export markets are not in general composed of those products one would closely associate with the knowledge-based economy. The top three products with the fastest growing market share are floor coverings, pork and poultry fat, and hemp. On the other hand, if one looks at products where market share is in major decline (>10% loss in market share), the EU has many more (345 product groups) than the US (65) and Japan (90).[76] What is more, in Europe many technological products are among them (e.g. air launchers, turbines, insulating glazing, drugs containing alkaloids or hormones, telephones, photographic film).

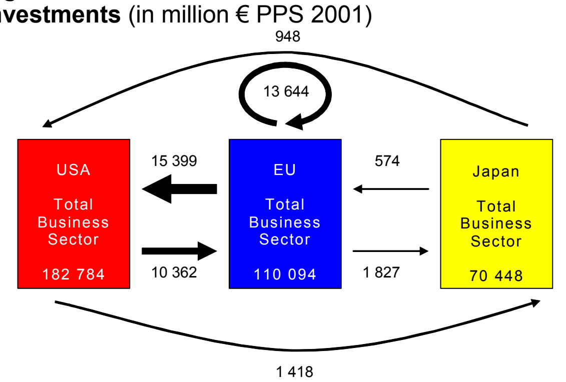
With the emergence of new players in global markets, Europe will not be able to base its future competitiveness on cheap labour, but must perform better in exploiting knowledge and in creating new high-value-added products and sectors. As described in the Kok report, raising European competitiveness should be based on sectors where comparative advantages already exist. A revitalized Lisbon process and an increase in research investment, both at national and at EU level, will be vital in achieving this aim.

Section 2: Should the European Research Area be better organised?

The already negative effects of Europe's relatively low investment in research as described above are compounded by a number of structural deficits inherent in the European R&D system. The way the system is organised leads to inefficiencies which make Europe less attractive than it might be for R&D investors and researchers. Fragmentation of R&D funding across the Union, diversification of efforts and insufficient coordination of research activities are factors which, in the end, impact negatively on Europe's attractiveness.

The EU attracts most of the world's foreign direct investment.[77] Its macroeconomic stability, the quality of its labour force, and the size of its market (400 million consumers with substantial purchasing power) make the European economy attractive for foreign money. But Europe does not attract most of the world's foreign R&D. Quite on the contrary. Even private European firms themselves finance more R&D in the US and Japan than they do in other countries in the EU. And US and Japanese enterprises invest less in Europe than they get from it. In 2001, for instance, the US attracted one third more business R&D expenditure from EU companies than it allocated to the EU. And EU firms spent almost four times more on Japanese research than Japanese companies did in the EU-15 (figure 10). These data imply that in 2001 alone there was a net outflow of R&D funding amounting to nearly € 5 billion to the advantage mainly of the US research system.[78]

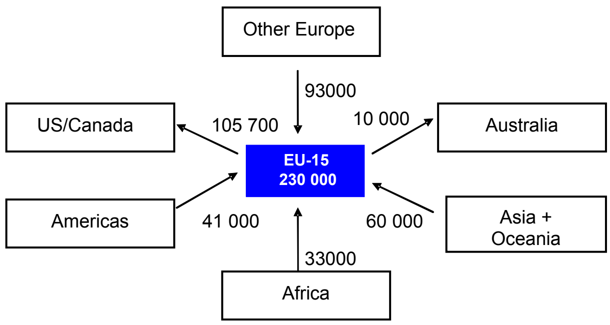
Figure 10: Attractiveness of the EU for R&D investments (in million € PPS 2001)



Source: OECD, Activity of Foreign Affiliates database and Secretariat estimates

The situation is similar for the flow of researchers: Europe does not succeed in retaining or attracting the best researchers. An increasing number of highly skilled S&T personnel is lost by the Union to industrialised countries such as the US, Canada and Australia. By 2001, for instance, more than 400 000 non-immigrants were admitted to the US on a temporary basis came from the EU.[79] The more than 22 000 EU-born admitted to the US in 2002 as temporary workers (H1-B) mainly helped fill the demands for education, engineering and computer occupations. Unfortunately, Europe does not sufficiently succeed in encouraging its own researchers to come back after a foreign sojourn: Nearly 75% of European PhD recipients plan to stay in the US after their PhD.[80] At the same time, Europe appears to hold much less of an attraction notably to US researchers while being a popular destination for scientists from the developing countries.[81]

Figure 11: Attractiveness of the EU for R&D personnel (2002)



Source: Third European Report on S&T Indicators 2003

The way the European research and innovation system is organised needs to be changed so that Europe becomes more attractive and efficient. Three aspects appear particularly relevant: The European R&D system must further open up; its framework conditions must become more coherent and conducive to private investment; and, finally, Europe must better co-ordinate its national research efforts.

A more open system

In order to reverse the net outflow of researchers and R&D spending, the European research system must become more open. The barriers to the circulation of people and to the dissemination of knowledge need to be removed.

It has to dramatically improve its attractiveness to researchers, next to ameliorating the regulation of access to Europe of third country researchers. Today, the EU overall does not offer particularly advantageous work conditions for researchers (such as salary and benefits, longer term career perspectives and physical work environment). Its employment market and research careers are still mainly nationally determined. There is no transparent European-wide recruitment system. A number of Community initiatives, implemented with Member States and other stakeholders, have already been taken with regard to researchers' careers, to assistance to researchers and their families[82] and with a view to reach out to and network European researchers abroad. These represent significant steps in the right direction, but the efforts towards the realisation of an open, competitive and trans-national employment market need to be intensified. For example, recent US data reveals that among the top

10 supplying countries of H1-B temporary workers admitted in 2002, UK workers report a median income of US$ 68 000, second only to the US$ 70 000 reported by Canadians and well above the top-10 average of US$ 53 000 they would earn in their home country. On the entry conditions of third country researchers, efforts towards the adoption of European wide immigration provisions must be actively pursued.[83] Combined with a substantial and targeted system of grants for researchers at different stages of their careers, with built in trans-national, international and intersectoral mobility the European actions in human resources should help to remedy the current situation and improve Europe's attractiveness for the best researchers from within and outside Europe.

Shortcomings can also be observed in the diffusion of knowledge: the European Research Area as a space for the free circulation of knowledge is not yet a reality. There is intensive scientific co-authoring among EU countries, which is a good indicator of the integration of the ERA.[84] But the EU would appear to be less open than other regions (such as EFTA, Israel and South Africa) when it comes to international co-publications.[85] Experience shows that the Framework Programmes are not only an engine for scientific production, but they also foster scientific collaboration. Therefore, measures need to be taken both to further encourage trans-national and international cooperation via the FP and to foster the exchange of human resources as an instrument of information diffusion and technology transfer.

Data on patents submitted by European and third country researchers together provide an indication of the extent to which EU countries co-operate internationally. Evidence shows that foreign firms co-patent less often in Europe than is the case the other way round.[86] International co-patenting numbers are still low relative to the level of patents issued annually in the US. Taken as a whole, the EU-15 has a lower proportion of foreign co-inventors than the US.[87] It would appear that Europe's poor attractiveness for foreign private capital is linked to insufficient competitive framework conditions and legal obstacles.

More competitive framework and fiscal conditions

Harmonised and attractive framework conditions - such as tools to protect intellectual property, an environment with research and innovation-friendly regulations and competition rules, supportive financial markets and a favourable fiscal environment - can play a key role in leveraging foreign R&D investment. Innovation does not only depend on scientific research and technological development, but also on the conditions which facilitate the transformation of knowledge into innovation and marketable products and which guarantee legal certainty.

Such harmonised conditions and innovation-friendly rules are not yet in place in Europe. The same rules do not apply throughout the Union. This disparity is a major obstacle repelling foreign investors.

For instance, the "innovation gap" between the US and the EU might more appropriately be described as a commercialisation gap: Europeans are at least as innovative as others, but are often weak in deriving the economic benefit of their inventiveness. In Europe, the gap between success in the laboratory and success in the market place is – at least in part – due to the fragmentation of the European patent systems. In many sectors, firms would invest more in R&D if their intellectual property could be better and more cheaply protected and if they could expect to reach sufficient returns to balance the risk inherent in such activities. The absence of a standard Community patent to cover all the European territory and provide affordable legal certainty to investors is a major disincentive especially for SMEs and the academic sector.[88]

With regard to fiscal conditions too, Europe is far from having a harmonised system. Taxation and incentive structures vary across the EU. For instance, national fiscal incentives for private investment to encourage business to invest in R&D are still different across Europe, although they are now reaching substantial levels (around 12.5% of public spending on research in the Netherlands, 16% in Austria and 42% in Latvia).[89] This diversity can give rise to unhealthy tax competition.

In order to ensure that framework conditions are attractive for private investment in research in Europe, improvements are needed in the areas of product market regulation and standardisation, competition rules, financial markets, the fiscal environment and S&T human resources. New initiatives are underway both at Community and national levels. In the area of industrial property, mainly an area of Member State competence, the application of the Open Method of Coordination has resulted in mutual learning and will lead to the development of EU guidelines. In the area of competition rules, an exclusive Community competence, the framework for R&D State Aid will be revised in 2005 to adapt to changes in the research environment. In the area of product regulation, a shared competence, the impact of the introduction of new legislation is being assessed both by the Commission and the Council. Also the setting of clear policy objectives, priorities and targets can provide for legal and political certainty to allow the private sector to invest into longer term oriented research.

Better co-ordinated research efforts

There is a third structural deficit: the national public research policies of EU Member States are still insufficiently coordinated. There is still considerable fragmentation and diversification of research funding and activities. Four years after the launch of ERA, it cannot be claimed that there is a genuine European S&T policy. Unlike the US or Japan, European research still represents a jigsaw of national public systems. National activities, governed by 25 varying legislative, regulatory and financial structures, are still largely undertaken independently of one another. Such compartmentalization leads to an inefficient allocation of resources and a thinner spreading of research efforts than would be the case under a better co-ordinated system.

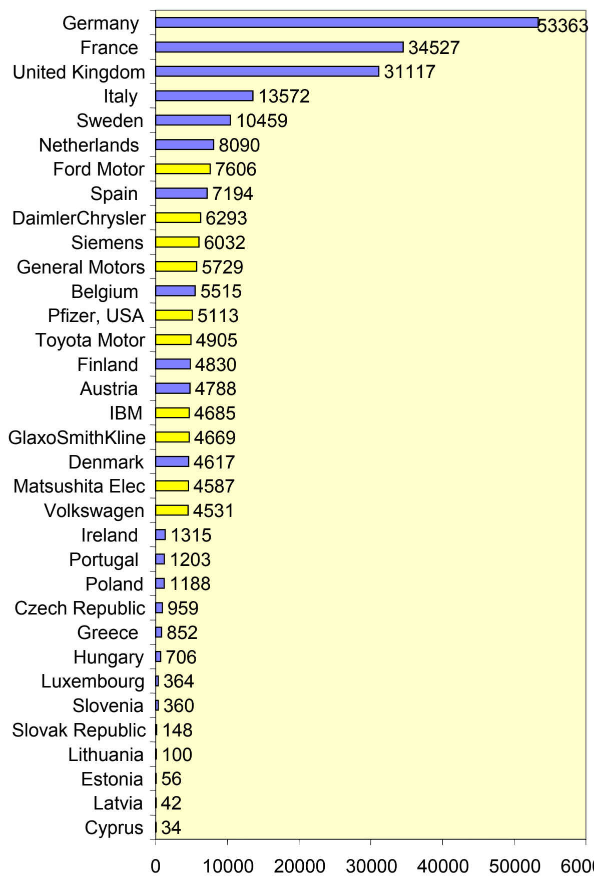
In concrete terms, relative to their GDP, some Member States spend a lot on R&D, while others invest at a much lower scale. Sweden and Finland, for example, spend over 3% of GDP in research, whereas 8 Member States invest less than 1%. However, even the best in the European class are outperformed at the international level. If one compares EU countries to the top 10 US states in terms of R&D intensity, then its best performer, Sweden, would rank only 6th. The EU's second best, Finland, would not reach the top 10. The same applies for the average annual R&D spending of an EU country: at just € 7 billion, this compares modestly with the Ford Motors company's investment of € 7.8 billion (see figure 12).[90] Apart from the fragmentation of funding, the diversity among Member States induces a wasteful duplication of research efforts. At present, practically all Member States have their own national and regional research programmes. They lose valuable resources by setting similar priorities and investing in the same expensive facilities.

The example of basic research illustrates these issues. Its funding is dispersed across the Union, and consequently, many projects lack the necessary critical mass. The amount spent by Johns Hopkins University on basic research exceeds the individual efforts of 18 EU Member States, and is greater than the combined efforts of the 10 new Member States[91]. The prevalence of national rather than European-wide funding mechanisms leads to a lack of competition in Europe. Moreover, co-ordination of activities is limited due to the compartmentalisation of national programmes and support systems.

What can the Union do? At Community level, it already successfully helps to compensate for this insufficient coordination. This is mainly done via the Framework Programmes which offer cooperation tools and set thematic priorities. For instance, funding of trans-national collaborative research under the FPs has a positive impact on the co-ordination of research activities across the Union (see chapter 4, section 2). However, the financial support the Community can offer today is limited. Community efforts still represent a 26th research policy, in addition to national efforts. Equipped with a budget of only around 6% of national public R&D funding, they cannot be sufficiently dynamic to have a truly integrating effect on national policies. At intergovernmental level, where there is no efficient collaboration either, the Union can help by bringing together actors with the Commission acting as a catalyst. The Open Method of Coordination as defined by the Lisbon Council proves to have the potential to be a successful policy-making instrument in the research field. Its application through CREST has resulted in a number of recommendations in key policies areas.[92] But further efforts are needed.

Acting alone is inefficient and prevents EU research efforts from achieving the necessary critical mass of human, technological and financial resources. Size does matter in the economic and technological performances of countries and systems, even more in the globalized economy.[93] The EU must therefore ask itself what are the costs and benefits of maintaining 25 separate research systems. In order to meet the American, Japanese and upcoming Indian and Chinese challenges, the choice is not to become a federal state with a central S&T policy. Nor is it to remain the jigsaw of 25 independent national policies. The EU needs to become a set of scientific states competing with one another while at the same time, within the context of ERA, collaborating effectively to joint advantage. Against this background, action at Community level is urgently needed. In order to overcome the fragmentation of research efforts, a substantial increase of the research budget at Community level is called for: FP prove to be a particularly successful instrument to enhance trans-national collaboration. At the same time, cooperation activities at intergovernmental level need to be expanded.

Figure 12: Total R&D expenditure of the 25 Member States compared with the top 10 R&D spending multinationals (2002, € billion)



Source: DG RTD, Eurostat Data: OECD, Eurostat, UK R&D Scoreboard
Notes: (1) LU: 2000; GR, IRL, BE, NL, SE, IT: 2001; (2) EU-25 was estimated by DG Research and does not include LU and MT; (3) MT is not included due to unavailability of data

Chapter 3: European value added of Community intervention

The above chapters have demonstrated that Europe is facing a wide range of challenges in the economic, social and environmental fields. Evolutions and dynamics within the scientific field itself also pose their own challenges. As it appears, European S&T is not in the best position to meet these challenges. Europe is showing pointed weaknesses in the field of science, technology and innovation performances, while the organisation of the European innovation system can also be improved.

Because of the existence of so-called market and system failures, the public sector has an important role to play in the improvement of European science and technology. The choice of the most adequate instrument of intervention requires careful consideration, however. R&D subsidies are among the most common and effective instruments, provided that they are designed in a careful manner.

Section 1: Is there a role for government intervention?

Developed country governments all over the world directly support business R&D through the provision of subsidies. But the extent to which they do so varies. OECD country governments finance around 8-10 per cent on average of business expenditure on R&D. Between 1991 and 2001, such support totalled $ 35 billion per year for all OECD countries together.

In the EU-25, direct government funding accounted for 7.5 percent of business R&D in 2002, the US percentage being substantially higher and the Japanese one substantially lower. Over the past few years, the importance of direct government funding of business R&D has decreased somewhat due to the increasing importance of indirect support in the form of tax breaks.

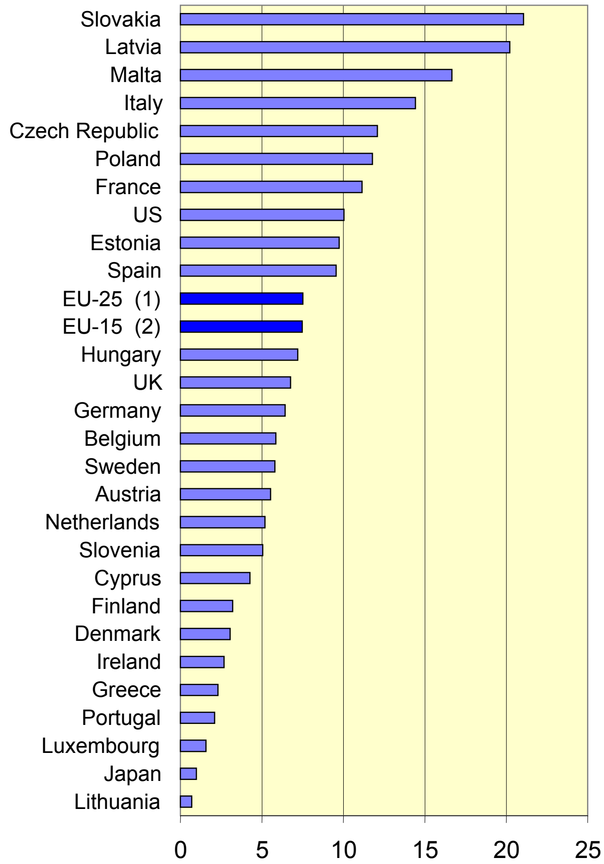
Public support for research is fully justified

Market failures, which prevent the private sector from investing in research at the socially optimum level, generate a need for public support for research.

A first market failure concerns uncertainty. At the start of a research project it is not at all sure whether the research efforts undertaken will actually result in new knowledge and innovation. Such uncertainty derives from technical complexity, time considerations, and capital intensity.[94] This issue is particularly important in basic research and in emerging areas – entrepreneurial and dynamic research generally carries a high degree of scientific/technical risk, as multiple new directions in research are explored, before stable technological trajectories can be established.

Another market failure results from the fact that, even if the research initiative gives rise to new knowledge and innovation, it is not at all sure that the researcher or company that has undertaken the research efforts will be able to exclusively appropriate all the benefits deriving from it. Significant positive externalities exist in the form of important knowledge spill-overs.[95] In other words, knowledge and innovation have some of the characteristics of a public good, i.e. something that can be simultaneously consumed by everybody in a society. The consumption of a public good is non-rival (one person consuming it does not stop another person consuming it), non-excludable (if one person can consume it, it is impossible to stop another person from consuming it), and non-rejectable (people cannot choose not to consume it even if they want to). The combination of non-rivalry and non-excludability leads to private underinvestment in research and justifies government intervention such as the provision of subsidies.

Figure 13: Share of BERD financed by government (latest available year)



Source: DG RTD, Eurostat Data: OECD, Eurostat
Notes: (1) AT: 1998; LU: 2000; DK, EL, IE, NL, PT, SE: 2001; DE, IT, US: 2003; (2) EU-25 does not include LU; (3) EU-15 does not include LU.

Companies may also be reluctant to invest in research out of fear that the new products they may come up with may make obsolete the products they are currently deriving substantial profits from.[96] The provision of public support may affect their calculation.

A good example of another severe market failure is provided by a recent NBER study, which examines why private pharmaceutical companies carry out very little research on the development of vaccines for tropical diseases such as malaria, tuberculosis, and African stains of HIV. Michael Kremer argues that the reason is that the companies fear that were they to develop such products, governments would force prices down to a level that would not allow them to earn a satisfactory return.[97]

These kinds of market failure mean that government incentives are needed to stimulate private research and reduce the difference between the private and public rates of return in order to obtain the optimal levels of research in the economy.

The need for public support of research also derives from the system nature of innovation, and from the importance to invest in human capital and networks to ensure the absorption of knowledge. The process of knowledge production is much more complex than the linear model suggests. There are many feedback effects between the various stages in the innovation process, which is best considered as a system, where institutional relationships and the flows of knowledge between actors in the system are of critical importance. The literature that analyses national systems of innovation stresses that the innovative performance of a country, and thus its growth potential, depends upon the development of a balanced 'system' of knowledge production and distribution.[98] Co-ordination and institutional failures can also occur and justify the intervention of the government. The role of government then is to invest in human capital, intensify relationships, and optimize the flows of knowledge.

Optimising the R&D policy design

Once the decision has been made to intervene, this should be done in the best possible way. Government intervention can remedy some of the aforementioned market failures. But government intervention itself can also fail and social costs end up higher than social benefits. Examples include institutional inertia, a lack of reliable information (e.g. on the impact of policies), a lack of continuity and a long-term perspective, excessive red tape, bureaucratic rivalry, unintended side-effects, etc. Therefore, the benefits of solving markets failures must exceed the costs of government failure.

Thus a careful policy design is required so that R&D support is provided in the most appropriate areas (with large spill-over effects and where the private sector would not get involved on its own) and through the most effective instruments. A wide range of tools are available to optimize the research policy formulation process. These include the comparative analysis of S&T input and output indicators; foresight and technological assessment analysis; the benchmarking of national R&D policy actions and instruments; growth and competitiveness analysis; the consultation of stakeholders; the evaluation of the management and impact of past R&D programmes; and impact assessment and ex ante evaluation.

First, a careful choice has to be made as to the area of intervention. The combination of finite resources and a multitude of new emerging research opportunities means that careful attention must be paid to funding priorities and requires wise choices by policy makers. Is R&D support provided across the board, to all S&T areas, or is it concentrated in a smaller number of S&T priorities, and if so which ones? Is R&D support provided in research infrastructure, basic research, applied research, and human resources too, or is it concentrated in a single or just a few components of the innovation system, and if so which ones?

Second, the right choice has to be made as to the instrument of intervention. A wide range of possible instruments has emerged since the shift from the linear to the innovation systems paradigm.[99] Governments make use of a flexible and evolving toolkit of instruments adapting to the specific dynamics and composition of the innovation system and addressing existing bottlenecks in the system.[100,101] The Innovation Policy Trend Chart lists around 1340 instruments used in 28 countries.[102] These instruments can be classified according to different dimensions. Direct measures, for instance, are targeted at a specific scientific or technological theme, discipline or sector, while indirect measures refer to all sorts of schemes that sustain and reduce the cost of RTD investment. Financial measures, such as tax credits or VC, give monetary support, while non-financial measures are aimed at improving the framework conditions: the legal framework, increasing attractiveness of science among boys and girls at all levels of schooling, an attractive environment for high quality researchers and research careers, raising public awareness and understanding of S&T, etc. Supply side policy measures are intended to provide a transfer to firms of the resources and capabilities needed for innovation, while demand side policy measures seek to increase the demand for innovative goods and hence increase the incentive for firms to perform R&D.[103] Paul Romer argues that, historically, policy has focused too one-sidedly on stimulating R&D via tax credits or subsidies. However, if the supply of R&D resources – primarily technically trained people – adjusts only very slowly to increases in demand, then such policies will raise the wages of scientists and engineers without increasing research much. Effective government policies aimed at increasing the supply of scientists and engineers might counter these tendencies and ultimately increase the rate of commercial innovation and economic growth.

Care should be taken not to introduce an excessive number of different instruments and to maintain a well understandable policy framework. Consistency across instruments should also be ensured. Different instruments can work together to alleviate a particular problem, or they can counteract each other, sometimes in unanticipated ways. For instance, if fiscal incentives are too high, the attractiveness of grants and their impact are reduced. The policy mix chosen should also aim to maximize different kinds of benefits.[104] A first kind of benefit is that of input additionality, or whether resources provided to a firm are 'additional', that is to say whether for every Euro provided in subsidy or other assistance, the firm spends at least one an additional Euro on the target activity. If not, the public support is crowding out private funding. Another kind of benefit is that of output additionality, or "the proportion of outputs which would not have been achieved without public support, measured in terms of patents, market share or profitability. A final kind of benefit is that of behavioural additionality, or change in the behaviour of a particular innovation actor as a result of public intervention. Behavioural additionality has been developed as an alternative criteria to measure the effectiveness of policy instruments in the context of their role in the innovation system and the specific objectives or targets groups they address, also referred to as 'catalyst' effects of public support.[105]

The effectiveness of the policy mix should be considered in the context of the innovation system and the pursued objectives. Evaluating the effectiveness of the different policy measures is important for several reasons. It helps to learn from the past; it helps to design or improve the policy design, programmes and initiatives; it provides periodic assessments of their intended and unintended effects, it justifies the continuation or cancellation of a policy/programme, etc.

Providing support at the right policy level

Policy support has to be provided at the most appropriate level, and consistency in support has to be ensured across all policy levels. In a world that is increasingly interlinked, government measures will generate effects that go beyond the sheer local, regional and national level. Multi-level governance means finding the most optimal combination of government intervention at all policy levels in order to create synergies which none of the policy actors will be able to achieve on their own. Research policy can only be effective if a multi-level governance approach is applied both in designing and implementing as well as in evaluating the success of the policy.

Section 2: Why should this intervention take place at European level?

As described above, a compelling case can be made for public intervention in R&D. However, when considering the FP, one must also justify why this type of public intervention is better carried out at EU level rather than at national level. Before analysing the reasons for EU intervention in research, one should first consider the legal basis for action at EU level. Articles 163 to 173 of the Treaty establishing the European Union describe the objectives of EU RTD and define the Framework Programme as the basic mechanism for implementing this policy (see the overview in II. 4.).

The text of the Treaty is of course the basis, but not the sole justification for EU intervention. The essential rationale for the FP is that it finances activities in areas that will benefit from public sector support, and, crucially, that these activities can be more effectively carried out at a European level. In other words, the FP should target funding on those actions that can produce a value over and above that which could be achieved through regional or national programmes. European added value is in reality a complex concept which has been the subject of much discussion. Nevertheless, there is broad agreement on a number of particular cases where EU intervention is justified. These can be regrouped in three main categories:

- *Pooling and leveraging of resources*
- *Fostering human capacity and excellence in S&T through training, mobility, career development and competition at European level*
- *Better integration of European R&D*

Pooling and leveraging of resources

Critical mass

Some research activities are of such a scale and complexity that no single Member State can provide the necessary financial or personnel resources. They need to be carried out at an EU level in order to achieve the required "critical mass". This occurs where a large research capacity is needed and resources must be pooled to be effective, or where there is a strong requirement for complementary knowledge and skills (e.g. in highly inter-disciplinary fields). Given the rising costs of carrying out R&D[106], economies of scale and scope are increasingly important.

FP projects tackle this problem by establishing international consortia that bring together resources and expertise from many Member States and research actors. The average FP6 shared-cost project has a budget of € 4.6 million and involves more than 14 participants coming from at least 6 Member States, often combining universities, public research centres, SMEs and large enterprises. FP6 projects are substantially larger than those under FP5, and one can now speak of an even greater critical mass effect than before (see II. 4.1.).Such multinational and multidisciplinary research projects would be difficult to manage at national level, and lend themselves naturally to EU level intervention.

Leverage effect on private investment

There is considerable evidence that public funding of R&D carried out by enterprises leads to what is called a "crowding-in" effect on investment: in other words, it stimulates firms to invest more of their own money in R&D than they would otherwise have done. A recent study estimated this that a € 1 increase in public R&D investment induced € 0.93 of additional private sector investment (see box below). In the case of the FP, there is evidence that many projects would not have been carried out at all without EU funding. The table below summarizes results from a number of recent studies. The consistent picture is that in approximately 60-70% of cases the FP enables research activities to take place that would not otherwise have occurred.

Table 2: Additionality of FP: Participants that would have abandoned the project without funding

ATLANTIS 5 year assessment (2004)	**58%**
NIFU et al. (2004) FP5 Norway	**95%**
AFSK (2000)- FP4 Denmark	**90%**
Technopolis (2001) FP4 Austria	**70%**
GOPA - Growth programme (2003)	**65%**
Technopolis (2004) – FP5 UK	**70%**
Technopolis (2001) FP4 Ireland	**82%**
Uotila et al. (2004) FP5 Finland	**75%**

Source: DG Research

EU support for R&D encourages a particular type of research project, in which private companies can collaborate with foreign partners at a scale not possible at national level, in projects tested for excellence, and gain valuable access to complementary skills and knowledge. It is therefore reasonable to conclude that the attractiveness of EU schemes induces firms to invest more of their own funds than they would under national funding programmes.

The debate on input additionality

An important debate focuses on the input additionality of R&D subsidies. This principle demands that public subsidies to firms are transformed into an increase in their research and innovation effort; and that they do not merely substitute private expenditure that would have been made in any case (Garcia-Quevedo). The findings in this regard have been positive. Econometric results obtained from several studies at both the micro- and macro-levels tend to be running in favour of findings of complementarity between public and private R&D investments. Studies conducted at firm level were more likely to report net substitution or crowding-out than were studies carried out at a higher level of aggregation. Crowding out was also a common finding in US studies.[107] A large majority of studies conducted in other countries found complementarity between public and private R&D. Of the 74 additionality studies studied 55 had significant results. The majority (38) of the studies (mostly European) concluded that R&D support was complementary to business R&D while 17 studies (mostly American) concluded that there was a certain degree of substitutability. The effect of subsidies is also longer term than that of tax incentives. A recent study has shown that publicly funded research appears to complement privately funded research rather than crowding it out. Using industry-level data for EU countries for the period 1987-1999, estimations suggest that government-financed R&D expenditures complement domestic industry-financed expenditures on R&D. In terms of marginal impacts of public funding, 1 euro increase in government financed R&D produces an additional 0.93 euro in domestic R&D.

Large-scale European projects enable participants to access a much wider pool of firms in their own industry than would be possible at purely national level. This mechanism offers clear advantages to enterprises compared with national level schemes. It broadens the scope of the research, and allows for a division of work according to each participant's field of specialization.

It also considerably reduces the commercial risk, because involving key EU industry players helps ensure that research results and solutions are applicable across Europe and beyond, enables the development of EU- and world-wide standards and interoperable solutions, and offers the potential for exploitation in a market of 450 million people.

Examples of pooling resources and knowledge

Nanobiotechnology: launched in 2004, the NANO2LIFE project is one of the first FP6 Networks of Excellence. It supports interdisciplinary research into nanobiotechnology tools and techniques. The convergence of inorganic nanotechnology and biotechnology into nanobiotechnology has the potential to yield breakthrough advances in medical diagnosis, targeted drug delivery, chemicals screening, and environmental monitoring for pollutants and toxins. However, progress depends on a multidisciplinary approach and assembling a critical mass of research effort over a period long enough to achieve meaningful results. This is the aim of the NANO2LIFE project, which is a joint initiative of 23 significant European players in various nano- and biotechnology fields, including three hospitals close to end users. It will involve a total of more than 170 researchers from 12 EU and associate countries. In addition to the full partners, the consortium has 31 associate members, including EU industry – mostly SMEs, used to working with academics – as well as research groups in Australia, Canada, China, Japan and the US. Funding for the four-year term of the network is €13.04 million, with the EU contributing €8.8 million.

Rare diseases: rare diseases affect 20 million European citizens[108]. The low prevalence of rare diseases (it affect less than one person in 2000, which results in often only few cases per country) gives EU collaborative research a substantial added value by increasing the number of patients available for each research project and bringing together the scattered specialists with complementary expertise, for developing new diagnostics and treatments. The European CLUSTER on the Genetic resolution of Myopathies (FP5 project involving 13 partners from 6 different countries) merged the individual cohorts of congenital muscular dystrophy (CMD), thus achieving the largest collection of CMD families in the world.

Global Earth Observation: The first Earth Observation Summit of 2003, establishing GEO, declared the need for "timely, quality, long-term, global information as a basis for sound decision making." Its purpose is to enable improved and coordinated monitoring of the state of the Earth, increased understanding of dynamic Earth processes, enhanced prediction of the Earth system, and further implementation of international environmental treaty obligations.

Big science

By its nature, some scientific work involves massive investment (e.g. large research installations, databases…). Since the construction and operating costs of such facilities are high, it is inefficient for countries to duplicate these investments. EU intervention is justified in terms of providing support for transnational access to large-scale facilities, for the development of new instruments and equipment and for cooperation projects designed to improve the interoperability of installations and the complementarity of their activities.

Fostering human capacity and excellence in S&T through training, mobility, career development and competition at European level

Stimulating human capacity through researchers' training, mobility and European career development

EU actions (Marie Curie) provide a coherent framework to address research training and mobility at all stages of researchers' careers in both academia and industry, so helping to make Europe as a whole more attractive for researchers. National schemes have not played a strong role in promoting such transnational actions, because they are difficult to organize at Member State level. FP activities with coordination at an EU level have therefore been the principal driver. Carrying out such actions at EU level provides a more harmonized and thereby potentially stronger mechanism (in terms of its structuring effect) for achieving these aims than what would be possible through purely national schemes. From a cost-effectiveness point of view EU-level measures avoid the higher costs of bilateral arrangements between Member States, while providing a common framework which promotes reciprocity between countries.

Examples of large infrastructure projects funded under the FP

Neutrons - Integrated infrastructure: the Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy (NMI3) comprehensively integrates all aspects of neutron scattering and muon spectroscopy in Europe. It brings together 23 partners from 14 countries, including 11 research infrastructures. It will provide 12 different access activities, offering approximately 5000 beam days of access to 150 instruments, for 1700 users who will carry out 900 projects, as well as 8 joint research activities on enhanced instrumentation and techniques, and 4 Networking Activities to widely disseminate the results.

Astrophysics – New research infrastructures: the ELT DESIGN STUDY under FP6 aims at developing enabling technologies and concepts to support the eventual design and construction of a European extremely large optical and infrared telescope. It builds on current European leadership and gathers resources across the European academic and industrial communities. The whole astronomic community is united behind the ELT: its eventual construction will have tremendous spin-offs for research industries, industry and education, and will provide Europe with a unique tool to open a new world for the exploration of the Universe.

Against the background of a growing competition at world level, the actions aim at maximising, quantitatively and qualitatively, the human potential in research and technology in Europe, by stimulating the brightest people to enter into the research profession, to ensure that researchers stay in Europe and to attract the best researchers to Europe. The set of targeted actions aim at a considerable structuring effect throughout the European Union on the organisation, performance and quality of research training, researchers' career development, the participation of women in research and knowledge sharing in all domains of research addressed under the Treaty, explicitly including sustainable pathways between academia and industry (including SMEs) and between disciplines.

The actions, based on trans-national as well as on intersectoral mobility, underpin the development of a genuine European labour market for researchers with good career perspectives, in support of a beneficial "brain circulation", thereby limiting "brain drain" both within Europe and in a global setting.

Improving S&T capabilities

EU research can also play an important role in transferring skills and knowledge across frontiers. Research teams wishing to develop their S&T capabilities in specific fields can participate in top transnational teams, benefit from learning and synergies, and so become recognised world centres of excellence.

In addition, by operating across the entire European Research Area, EU research stimulates the development of new scientific domains and collaborative multi-disciplinary undertakings in a way that transcends the capabilities of individual Member States.

Example: EU Research training networks

The EU LOTUS Project: This is a multidisciplinary project to promote research training at the cutting-edge of plant science. It brings together nine research teams from seven Member States, providing training in the new, multidisciplinary research field of functional genomics. The group is investigating the molecular and genetic basis of mutualistic symbioses, which are the key to sustainable agriculture. Participants indicated that Commission funding has been valuable in two ways: providing training in this new area of research, and in bringing specialised groups together that were not collaborating before. The funding has been used for various activities including enabling trainees to spend time in a second network lab, and organising workshops where trainees can learn a new technology and network with other group members.

Marie Curie fellows: Two Marie Curie fellows, Gadi Rothenberg and Hubert de Jonge, from different countries, from completely different fields, decided after having met at the Marie Curie conference in 2000 decided to combine their research, creating a paradigm shift in monitoring soil and ground water contamination, a major research area for the "Sustainable development; global change and ecosystems". This project zoomed in four years from academic curiosity, through patents and papers, all the way to creating and successfully operating of the Danish manufacturing company Sorbisense, with a market value of € 800.000 (the Danish investment fund Ostjysk Innovation bought 25% of the company).

Competition in research

The level of competition in research varies according to the Member State or region, in both basic and applied research. In basic research, many fields of science are highly specialized, and there may be only a handful of top-level experts in a country, especially in small Member States. Thus, there can be limited competition between research teams at national level. Similarly, many industries are highly concentrated, and one needs to search at a global level for specialist firms who can compete in a given market or area.

Public R&D funding at national level can only provide effective competition in such cases when it is opened up to researchers from abroad. However, experience to date would suggest that the opening up of national programmes has been very limited and not easy to implement.

Intervention at the EU level, however, has proven to be an effective way of promoting more intense competition in research, leading to higher quality and excellence. The calls for proposals launched under the FP have stimulated competition between universities, companies and research centres across a wide geographical area: 30 countries participated in FP2, rising to 140 countries in FP5. Preliminary figures for FP6 show that 68 countries participated in the first call alone (see II. 4.1.).

The high levels of over-subscription for FP funds are further evidence of the intensity of competition induced by EU-wide calls for proposals. First data for FP6 indicate that around one in five proposals are retained for funding for the "Integrating and strengthening" area.

Better integration of European R&D

Facing pan-European policy challenges

Public policy challenges have increasingly taken a global dimension (e.g. environment, health, food safety, climate change) and can be faced only on the basis of a common scientific base. Given the shared interest and the scale on which these issues arise, such research activities are more effectively carried out at EU rather than at national level. The need has also been identified to support - by excellence in science, technology and innovation - community policies such as the all-embracing maritime policy.

For example, the EU Common Fisheries Policy requires a strong scientific base for fisheries management and for technical advice. Similarly, the EU needs an efficient and sustainable transport system if it is to become a more competitive global region. Inputs from Community RTD projects have played an important role in shaping EU policies.

Encouraging the coordination of national policies

As analysed earlier (see I. 2.2.), there is still considerable overlapping and compartmentalisation of national research efforts. Better coordination of policies can help to target public investments more efficiently and reduce fragmentation. EU funding exercises a "catalytic" effect on national initiatives and improves the coordination of the activities of the Member States in areas of common interest (natural hazards, climate change).

Carrying out research at an EU level

Certain fields of research, by their nature, are best explored in a comparative international context. For example, research in the social sciences often seeks to explore issues against the different historical, institutional and cultural backgrounds prevailing in different countries (e.g. European social diversity, migration, comparative economic studies). EU research mechanisms provide the opportunity to assemble international research teams, each with its own national expertise and insights, and to set up pan-European research tools such as cross-country surveys.

Dissemination of research results

Dissemination is one of the most important arguments for research at EU level. It is a critical complement to research itself. If results are not well disseminated, the value of carrying out research is seriously diminished. Indeed, one of the key justifications of public expenditure on R&D is to maximize the social return through ensuring the widest possible dissemination of research results. Moreover, in the context of the Lisbon objectives, research can only contribute to economic growth, to competitiveness and to job creation if the results are disseminated to the European business sector so that they can be transformed into new products, processes or services.

Carrying out this dissemination at an EU level – to users, industries, firms (SMEs in particular), citizens, etc. – is more efficient and leads to a better exploitation of research, with a larger impact than would be possible only at Member State level. Given the classical obstacles of language, proximity etc., when research is carried out at national level, it can be difficult for researchers abroad to access this new knowledge if no special incentives are provided. In addition, a country may generate important results in a particular area of science, but if it has no industrial activity corresponding to this discipline, then commercial exploitation may be severely hampered. EU-level research teams provide a powerful mechanism for disseminating results internationally. Unique and easy access to results through CORDIS enables knowledge to be shared with firms across all Member States and associated states, and to be exploited to commercial advantage. In 2004 alone, the CORDIS website had more than 2.5 million different users.

PART II: IMPACT OF THE 7TH RTD FRAMEWORK FROGRAMME

Give me a lever and place to stand, and I will move the world.

Archimedes

The first part of the report has examined how science and technology can contribute to tackling the challenges facing Europe, and has argued why EU-level intervention in support of R&D is necessary. Against this background, and at a time when the Union is expanding, it is clear that Europe must take some crucial decisions about how to organize its research system in the most effective way. EU-level support to R&D can play an important role in this system, and the arguments in favour of such support have already been presented. But what should be the precise form and scope of this support?

This second part of the report addresses this key issue, setting out the rationale for the design of the proposed FP7, analysing its expected impact (versus alternative policy options), and demonstrating how can it help Europe to achieve its main objectives in the coming years.

Of course predicting the future is never easy, but an obvious starting point is to take stock of the impacts of past Framework Programmes. Chapter 4, therefore, begins by presenting an analysis of the economic, social and environmental effects of the FPs to date. It is important to state these past impacts because the proposed FP7 is not a completely new mechanism, but rather contains many elements of continuity in relation to previous FPs, and so one might expect it to produce similar effects (albeit on a wider and larger scale). Moreover, one of the alternative options evaluated in chapter 5 is a continuation of “business as usual”, which would mean carrying on with the same level and types of impact as under FP6. Chapter 5 contains the core of the report: the assessment of the impacts of FP7 compared with those of two alternative policy options. This chapter sets out the main criteria used for designing FP7, and analyses its expected impacts on the EU economy, society and the environment, as well as its potential contribution to achieving the EU’s key policy goals set at Lisbon, Barcelona and Göteburg. Detailed results of econometric modelling of the potential impacts of FP7 on productivity, growth and employment are presented here for the first time.

FP7 also introduces a number of important operational innovations aimed at improving making it more user-friendly and effective. Chapter 6 explains the rationale for these changes, presents the new approaches and assesses their likely effects.

Chapter 4: Impacts of previous policy objectives and results from the stakeholders’ consultation

This chapter demonstrates how the Framework Programme has been a story of pioneering, collaboration, and success. The first section examines how the main characteristics of the FPs have evolved over time. The second section analyses the impacts of past FPs, not only in relation to the economy, society, and the environment, but also to the EU's S&T performance, as regards the different actors, and the European research and innovation system itself. The third section provides an account of the views of the stakeholders on FP7.

It should also be stressed that the FP is not the only Community activity providing support for cooperation in S&T and the removal of barriers to collaborative research in Europe. Other prominent initiatives include actions to improve access of 3rd country researchers, efforts to harmonise the R&D taxation system within the Union, cooperation with European Investment Bank (EIB) and European Investment Fond (EIF) to support venture capital funding etc.

Section 1: Evolution of the Framework Programmes from FP1 to FP6

This section provides an overview of how the main characteristics of the Framework Programme[109] - its budget, thematic priorities, participation structure etc. - have evolved since the first Framework Programme was launched in 1984 (for a brief history of Community research policy, see the box below).

A short history of EU Research Policy

European research policy goes back to the beginning of the European construction, although the Founding Treaties did not initially provide the Community with an extensive responsibility in the field. Until the late 1970s, research policy mainly consisted of sectoral initiatives in areas such as nuclear energy, coal and steel and agriculture.[110]

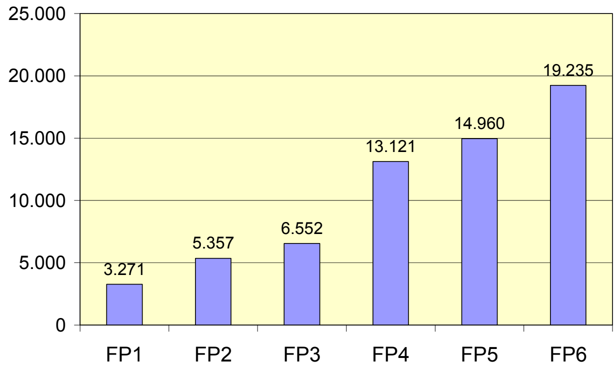
A true Community research policy, shifting from an ad hoc approach without an explicit legal base, towards an integrated vision for research only started in the 1980s, with the first EC Research Framework Programme (1984).[111] On the basis of the positive experiences with this first pilot FP, a separate chapter on research and technology development was included in the Single European Act in 1986.[112]

Since then research has been a Community responsibility with its own legal basis – and with the status of a fully fledged Community policy area such as economic or competition policy. The Maastricht Treaty further widened the Community role in R&D by highlighting its importance in upholding Europe’s industrial competitiveness, in fostering economic growth, and in developing research activities needed to implement other Community policies. More recent initiatives, such as the concept of a European Research Area (ERA) and the implementation of the Lisbon process are further developments of this train of policy. Indeed, this evolution is reflected by an explicit reference to ERA as the major objective of the Union research policy in the Treaty establishing a Constitution for Europe.[113]

An important introductory remark is necessary as regards the statistics on which the following observations are based. Methodologically, the available data do not allow for a thoroughly sound analysis over time. Harmonised and systematically collected data covering the period from the first to the current Framework Programme do not exist: either these are simply not collected or the definition of the object has changed from one FP to another. The latter observation notably makes an analysis of industrial participation difficult. However, regardless of these methodological problems, the findings of the analysis are striking.

- **A steadily increasing FP budget**: The growing importance of research among Union policies is reflected in the increase in EU funding for R&D. There has been a continuous increase in budget from one FP to another, with funding reaching € 19.2 billion for the four-year period 2002-2006 (see figure 1).[114] In 2004, R&D comprised almost 5% (4.83%) of the Community budget, and RTD now occupies third place in Community spending after the well-known agricultural and structural funding. One must bear in mind, however, that despite the important increases in the RTD budget, European funding represents only around 5.36% of total public funding for research in Europe[115]. In other words, about 94% of public funds for research are invested at national level. Given this comparatively small budget, the Union's R&D policy has been remarkably successful in the last 20 years. At the same time, the relative importance of FP funding should not be underestimated. As the Court of Auditors highlights in its Special Report on the management of FP5 indirect actions: "if institutional funding is deducted [from the annual national RTD expenditure], the budget for FP5 indirect RTD actions amounts to approximately a quarter of total funding for publicly financed research projects in the EU".[116]

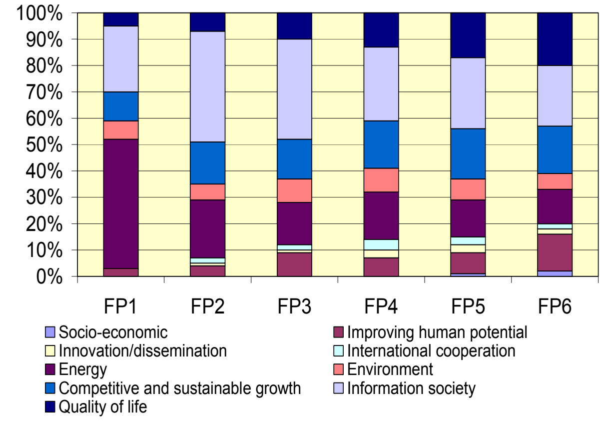
Figure 1: Evolution of the FP budget (€ million)



Source: DG Research

- **A growing diversification of priorities and themes:** While the first FPs put a clear emphasis on two thematic priorities – energy and ICT (accounting for 75% and 65% of funding in FP1 & FP2 respectively) -, subsequent FPs have been characterized by an increasing diversification of priorities (see figure 2). In addition, in recent FPs more attention has been paid to a horizontal and bottom-up approach in the definition of priorities.[117]

Figure 2: Evolution of Framework Programme priorities



Source: DG Research[118]

- **Approaching optimal project size – projects with a critical mass:** As can be seen from figure 3, the trend is towards a greater concentration of research efforts through larger projects with a critical mass. The average number of participations per project increased from 4.7 in FP2 to 6.6 in FP5 and over 14 in FP6.[119] The average EU funding per project increased from € 1.2 million in FP2 to 1.3 million in FP5 and 4.6 million in FP6. Thus resources are not spread thinly and the efficiency and effectiveness of the R&D system is improved. It is nevertheless recognized that areas, notably in the domain of very new, visionary science, require a highly flexible environment in which projects of moderate size represent a better investment.

Table 1: changing features of shared-cost research actions under the FPs

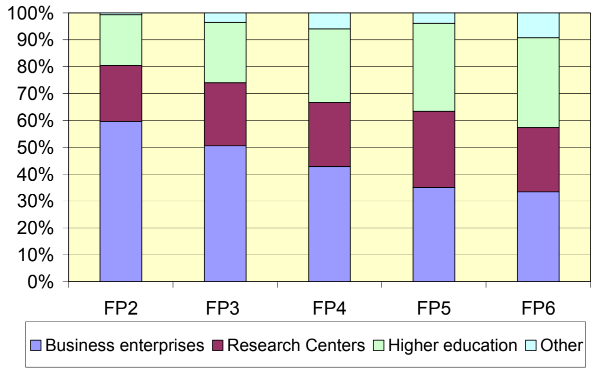
Indicators	FP2 EU12	FP3 EU15	FP4 EU15 [2]	FP5 EU15	FP5 EU25	FP6 EU25
	Definitive data	*Definitive data*	*Interim data*	*Definitive data*	*Definitive data*	*Interim data (first calls)*
N° of projects funded	2.779	3.292	2.949	7.331	7.334	484
Total n° of participations (000)	13	18	21	46	49	7
Average n° of participations per project	4,7	5,6	7,0	6,3	6,6	14,3
Average n° of Member states per project	3,0	3,5	4,2	3,7	4,0	6,7
Average EU funding per project (000)	1.202	1.218	1.160	1.332	1.332	4.602
Average EU funding per participation (000)	256	218	165	194	189	294[1]

Source: DG Research
Notes: (1) 294 with NoE; 349 without NoE (2) For FP4, only interim data are available (01.01.1994-31.12.1996)

- **The increasingly balanced participation of different actors in FPs and the place of SMEs:** Whereas most of the participants under the first two FPs came from big industry, a wider set of actors has been included since then, resulting in a more balanced participation structure by type of actor (figures 3 and 4). At present, FP participants include SMEs, public and private research organisations, universities and higher education institutes, and international organisations (such as OECD).

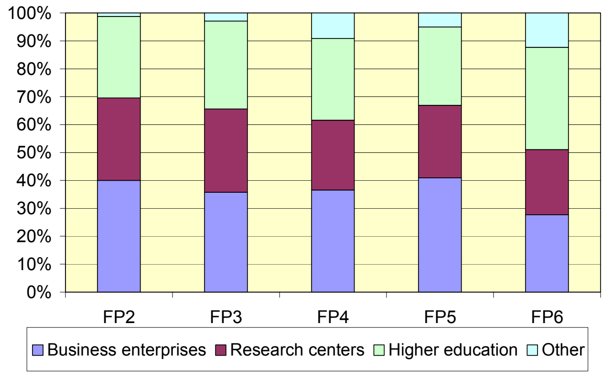
Across FPs, the participation from universities has increased at the expense of that from industry. This development can be interpreted as a shift from applied towards basic research and a larger emphasis on the long-term impacts of the FPs. However, participation by industry in the FPs and its commitment to R&D are critical to Community R&D policy. Therefore, since FP4, quantitative targets to SME participation have been set (5-15% in FP4 depending on thematic area, 10% for FP5). In FP6, at least 15% of the budget of the first and second Specific Programmes is foreseen for research performing SMEs. Their level of participation in FP6, overall around 13% in the first calls, varied among the different priority thematic areas, depending also on the level of SME activity and mobilisation in each area or sector[120]. Instruments such as STRePs, Integrated Projects and, to a lesser extent, Networks of Excellence are the major route for the participation of SMEs in FP6. This is, however, not unproblematic: The Marimon report on the "Evaluation of the effectiveness of the New Instruments of FP6" precisely pointed to difficulties for SMEs wanting to be involved in Networks of Excellence or to their disadvantaged positions in Integrated Projects.[121] As will be seen in chapter 5, the recommendations of the Marimon report have been taken up in the conception of the FP7 proposal. And new actions are being proposed for the business sector which will receive particular attention in the coming years.

Figure 3: Evolution of the share of FP funding by type of participant (shared-cost actions only)



Source: DG Research

Figure 4: Evolution of the share of FP participations by type of participant (shared-cost actions only)



Source: DG Research

- **Overcoming fragmentation - Integrating the European Research Area**: The FP constitutes an important tool for overcoming the fragmentation of the European research system. That is visibly demonstrated by two indicators:

First, the average number of different Member States participating in a single project has increased from FP to FP, showing that these projects bring together an ever more diverse group of countries. Starting from an average of 3 different Member States per project in FP2, interim data for FP6 show an average of 6.7 Member States per project (table 1). The stimulation of collaboration and long lasting coordination of R&D policies in Europe is one of the policy goals of FP6, which has been conceived as an instrument to realise the ERA. Two new large scale instruments (networks of excellence and integrated projects) have specifically been designed to move beyond the smaller projects favoured under previous FPs. FP6 also put an end to the trend whereby Community funding per participation in the FPs had progressively decreased (from € 256.000 in FP2 to € 165.000 in FP4).

Methodology for presenting the global configuration of Community collaborations

Figures a, b and c show the changes across FPs in the positioning of the Member States in Community collaboration networks. For each FP, a cluster analysis was performed on the correlation matrix of all Member State collaborative links. The results show the degree to which different countries have collaborated with each other (indicated by the percentages) and the relative importance of countries as preferred partner (indicated by the different zones). **They do not provide any indication of the importance of each country in terms of the absolute number of participations in the FP or the absolute number of links created with other countries through collaborative research projects.**

Percentages

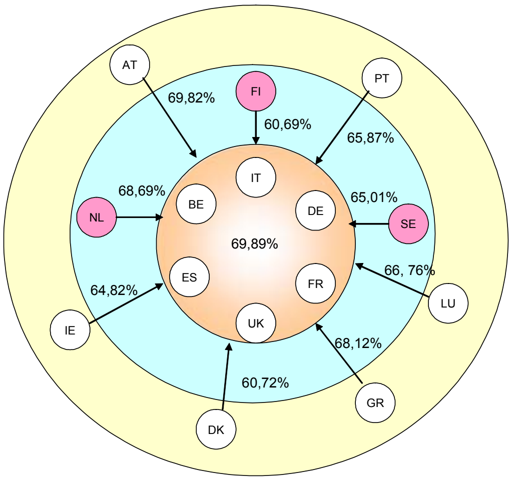
The percentages next to the arrows show the 'collaborative links' of a particular country with the countries situated in the orange zone. In FP5 for instance Italy had 50.45% of its collaborations with Germany, France, Belgium and the UK (and thus 49.55% with the other countries). The percentages inside the orange zone show the proportion of collaborative links that exist between the countries of that zone. In FP6 for instance all 8 Member States in the orange zone had 34.56% of their collaborations with each other (and thus 65.44% of their collaborations with other countries).

Three zones

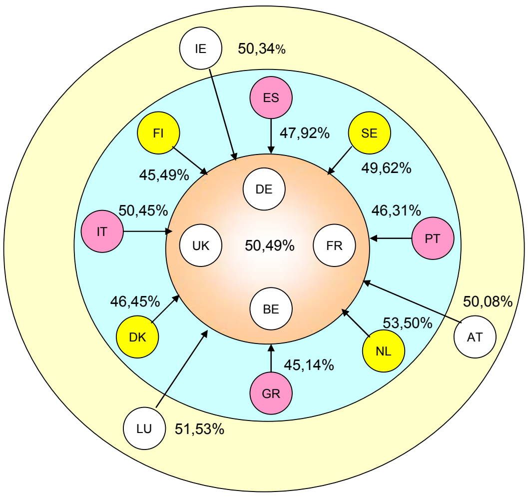
The central group - Countries situated in the orange zone: The countries situated in the orange circle are, first of all, very densely collaborating with each other. At the same time, these countries are also involved in collaborative links with the countries situated in the blue and pale yellow zones. This is indicated by the percentages in the figures.
The intermediate group - Countries situated in the blue zone: These countries are linked to the central group to an extent shown by the percentage figures. It emerges from the cluster-analysis that these intermediate countries also form one or more highly connected sub-networks, encased in magenta or ocher. Countries that are part of these sub-networks have dense collaborative links with each other (within the magenta and ocher cluster, respectively).
The peripheral group - Countries in the pale yellow zone: These countries are linked to the central group to an extent shown by the percentage figures and are not members of a particularly densely connected sub-network.

Figure 5: Evolution of the global configuration of Community collaborations

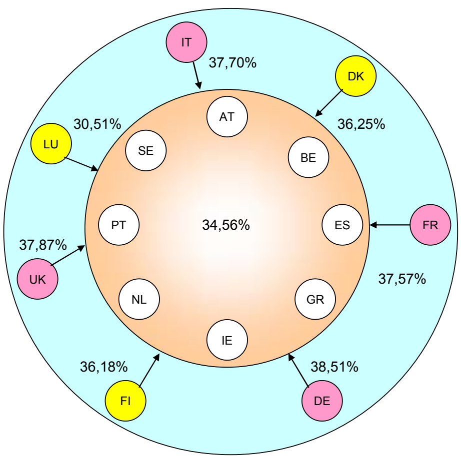
a) Fourth Framework Programme



b) Fifth Framework Programme



c) Sixth Framework Programme (data as of end of April 2004)



Source: DG Research

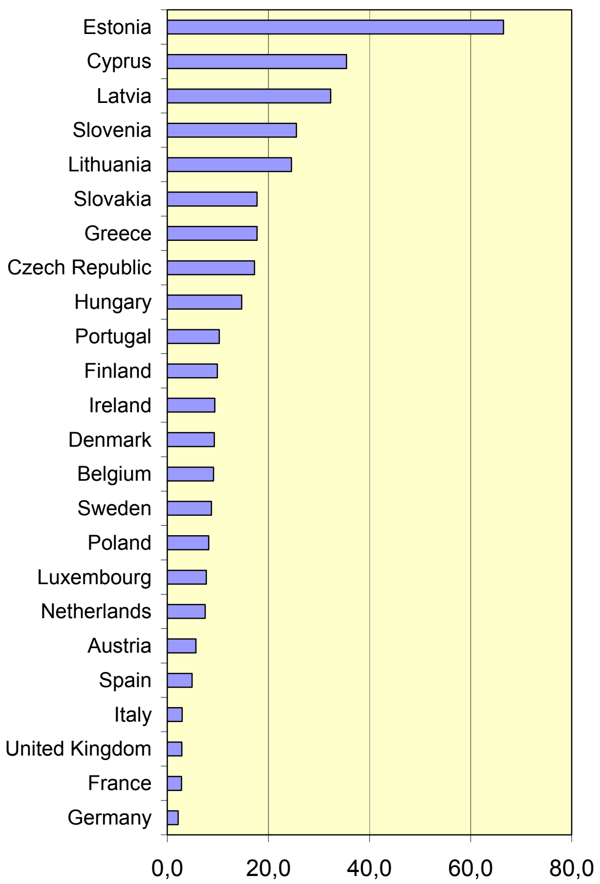
Second, the integrating effect of FPs is clear from figure 5 a, b and c, representing the changes across FPs in networking patterns between EU-15 Member States through collaborative research projects. Between FP4 and FP6, the nucleus has enlarged. The number of countries at the center has increased in 2002 to include eight Member States: Austria, Belgium, Spain, Greece, Ireland, the Netherlands, Portugal and Sweden. This is part of a wider trend. Indeed, it is also apparent from the configurations that the 'peripheral' and 'intermediate' countries too are becoming more integrated. Not only do they collaborate with the central group, but the intermediate countries are also collaborating more and more with each other. As a result, their collaborations have become more diversified and less dependent on the privileged group (also shown by the decreasing percentages from one FP to another).

The figure for FP5 clearly illustrated that two distinct sub-networks are organised around the nucleus. South-European countries (Greece, Portugal, Spain and Italy) often join forces, as well as the northern countries (Finland, Denmark, The Netherlands and Sweden). In FP6, peripheral countries such as Ireland, Austria and Luxemburg have joined the two inner circles of collaboration. Furthermore, in FP6 the integrative force of the Framework Programme has developed to such an extent that former peripheral and intermediate countries have replaced the central countries in the nucleus. The cohesion effect of the Framework Programme is clearly shown in figure 5c. Countries like Austria and Portugal have joined the core cluster. The configurations illustrate the shift from projects with a few countries (clustered by geographical proximity for instance) towards projects with more partners, with a wider diversity of partners. This trend, shown by the growth of the central zone while the peripheral zone fades out, as well as by the progressive decrease of all percentage figures, is one of integration of the European Research Area, with an increasingly networked and internationalised configuration of collaborations.

- **The increasing attractiveness of the FP to scientists worldwide:** Another indicator of the success of the FP and its global attractiveness is the growing number of participating countries from across the world. More and more countries participate: while in FP2 only about 30 countries took part, their number rose to 140 in FP5. At the same time, researchers' interest in FP projects has resulted in an increase in oversubscription rates calls and a declining success rate for applicants.

- **The FP as a win-win game - The FP 'knowledge returns':** The increasing number of participants and participating countries and the oversubscription rates provide convincing evidence that FP participation appeals to Europe's research community. One significant explanation for this vast interest is the fact that FP participation offers access to a wider network of knowledge. This enables participants to increase their know-how by being exposed to different methods, and to develop new or improved tools. Being part of an international consortium of highly qualified researchers offers spill-over effects that are more important than the monetary investment. This knowledge multiplier effect – estimated by comparing the total value of all contracts in which a country participates with that country's contribution to the FP – is demonstrated in figure 6. So if a country contributes € 1 to the FP budget, but the total value of all contracts in which the country participates is € 5 then that country has a net return or experiences a knowledge multiplier effect of € 4. Internal DG RTD calculations show that for € 1 invested in FP5, the net return on average was € 7.4 for the EU-15 and € 14.7 for the EU-25. Participation in the FP can therefore be considered as a win-win situation for all parties involved.[122] While all countries enjoyed positive knowledge multiplier effects under FP5, the size of these effects was roughly inversely related to the country's total number of participations in the FP. Countries with a smaller total number of FP participations (e.g. smaller EU Member States, the then Acceding Countries) enjoyed larger multiplier effects than countries with a larger total number of participations (e.g. larger EU Member States). This was the case because it is likely that a smaller total number of participations translates into a pattern of widely dispersed single participations per project, while a larger total number of participations translates into a pattern where regularly two or three participations from the same country can be found in the same project, which partially dampens the knowledge multiplier effect.

Figure 6: Knowledge multiplier effect of FP5 (net return in € for € 1 invested in FP)



Source: DG Research
Note: Malta not included; calculation: [(Value of shared cost contracts in which participating (no double counting))/Contribution to FP shared cost actions budget) – 1]; EU-15 contribution to FP5 shared cost actions budget calculated on the basis of their share in EU-15 GDP, Acceding Countries' contribution to FP5 shared cost actions budget calculated on the basis of then total contributions to FP5.

Section 2: Impacts of the previous FPs

Impacts on Europe's scientific and innovative performance

The aspects of S&T performance targeted by the FP include research and scientific progress as well as technological development and its application in production processes. S&T performance can also be measured in terms of the utilisation of research findings and the commercial exploitation of knowledge in new or improved products and services. Scientific and technological capabilities are equally linked to changes in behaviour towards research and innovation. The high level panel of independent experts which carried out the Five Year Assessment of the Framework Programmes (1999-2003) concluded that the programmes have played an important role in developing the European knowledge base over the period of the review[123]. Of course, there is a time lag before S&T measures such as the Framework Programme generate impacts on performance. That is why the analysis here looks at FP5, FP4 and even FP3 results.

The Framework Programme improves Europe's scientific performance

The number of scientific research publications is an indicator that serves well to provide an indication of the dynamism of the knowledge creation process. An external evaluation of some 1,200 projects under the BRITE-EURAM, Measurements and Testing, and Transport programmes completed in the period 1999-2001 found that the average output per project within 3 years after project completion consisted of 9 scientific publications, in addition to 2.5 qualifications (e.g. PhDs), 5 new tools and techniques, 4 demonstrators or prototypes, and 2.5 new projects.

On average, each FAIR project funded under FP4 in the field of nutritious foods, fisheries and aquaculture generated 9 peer reviewed scientific publications produced by 13 scientists and 4 students.

The FP5 International S&T Cooperation (INCO) programme, which brought together research fellows from the EU and developing countries, produced 582 peer reviewed articles through 105 projects, an average of almost 6 peer reviewed articles per project.[124]

The European fusion programme generates approximately 2,000 scientific publications per year, supports advanced training of researchers through 5-4 summer schools and workshops each year, and drives innovation, technology transfer and spin-offs, and the development of advanced technologies through a large number of industrial contacts.[125]

All these examples serve to illustrate the scientific importance of FP participation for Europe's researchers. Another indication of the catalytic role of FP funding in establishing a true European Research Area is the growth in co-publications by researchers from the European Union. Although the US remains an important scientific partner for most European countries, co-publications between EU and US researchers decreased between 1996 and 2001[126]. During that same time period, co-publications among (old and new) EU MS researchers increased noticeably as well as between EU and Japanese researchers.

That cross-border scientific collaboration within the EU has strongly intensified in the last decade is also demonstrated by the bibliometric literature. The overall strength of cooperative links has increased and the network of co-publication links has become denser, turning the EU into a strongly cross-linked cluster. There is more than one causal factor behind this phenomenon, but the FP is definitely among the determinants. Such publications also have a high impact: on average, international co-authorship results in publications with higher citation rates than purely domestic papers.[127]

As outlined below, research is a collaborative endeavour, and FP participation means participating in multi-partner, multi-national research teams. This is a feature that has been highly appreciated by FP participants over the years as consecutive Assessment and Evaluation Panels have reported. The benefits of FP participation have clearly outweighed the costs according to 72% of academics and 62% of industrial participants and 71% of respondents claimed they would not to have undertaken the work in the absence of the FP.[128] For FP4 participants it was found that 49% would be supporting their research with their own resources at the end of the activity and 43% would be using other funding[129].

Research collaboration is not limited to the academic sphere. Throughout the FPs, industrial participants and SMEs in particular received support to develop their RTD capabilities and to build partnerships with research organisations and industrial partners. The health and pharmaceutical sector serves as an excellent example for cooperation between industry and academia, due to its specific structure. Enhancing this type of collaboration has been a R&D priority from the beginning of the FPs. One illustration for a trans-national collaboration between academic clinical researchers and industry is an FP6 clinical trial project in children with renal failure. The project aims at developing a strategy for pharmacological renoprotection. The investigated drug has been provided by a pharmaceutical company and even though it is not a formal partner, the data will be used to seek regulatory approval for a label-extension.[130]

As far as small and medium-sized enterprises are concerned, the European SME community is considered very important due to its sheer size – 20 million SMEs in Europe account for two-thirds of employment – but also thanks to its role as incubator for new ideas and breakthrough innovations.[131] An independent study on the financial assistance schemes for SMEs found that FP5 achieved its goals relating to SMEs and contributed effectively to the constitution of European research and knowledge networks.[132]

The FPs are able to attract and bring together Europe's most outstanding scientists

The fundamental genomics programme funded under FP6, for instance, managed to involve no fewer than 6 European Nobel prize winners in its projects.[133] Nobel Laureates participated in at least 3 fundamental brain research projects funded under FP5. A total of 68 research teams focused on this topic, generating more than 70 scientific publications in high-impact international peer-reviewed journals.[134] As a result of one of these projects, new and promising avenues for therapeutic interventions were opened up. One of the winners of the 2004 Descartes Prize for Collaborative Research, Prof. Sir Richard Friend, was listed in TIME magazine in the Top 25 European Innovators 2003.[135] This prize was established in the year 2000 in order to encourage scientific and technological excellence, and is the major European reward for outstanding collaborative research in any scientific field.

The FPs improve Europe's innovative performance

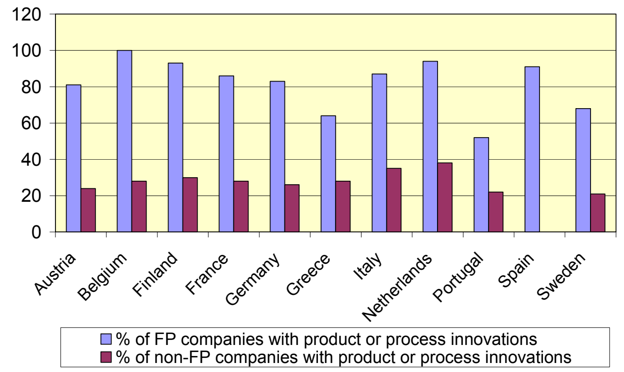
FP projects have been successful in producing positive impacts on innovative activity in Europe. Many projects lead to patents, pointing to an intention to exploit research results commercially. While the propensity to patent seems to be the same for the different types of FP actors, industrial participants are more likely to be involved in projects with an applied research focus (62% versus 17% being industrial partners) than pure basic research projects (17% industry participation).[136] In addition to the new knowledge described in patents, FP participation enhances the development and use of new tools and techniques; the design and testing of models and simulations; the production of prototypes, demonstrators, and pilots; and other forms of technological development.

A 2002 assessment of nearly 1,900 FP4 non-nuclear energy research projects showed that the programme resulted in about 400 patent applications. In about 30% of the projects some form of technical breakthrough was made; and about 60% of the projects resulted in significant technical advances beyond the state of the art. Also important, especially in the light of behavioural additionality, was the involvement of 1,600 new partners not previously involved in RTD activities.[137]

In 19 percent of genome-related research projects financed under FP5 a patent was filed, while in 53 percent the expectation was that an application would be filed. Knowledge-sharing was key in facilitating this innovative performance: in 61% of the projects shared databases were established while in 49 percent of the projects shared bio-banks were created.[138]

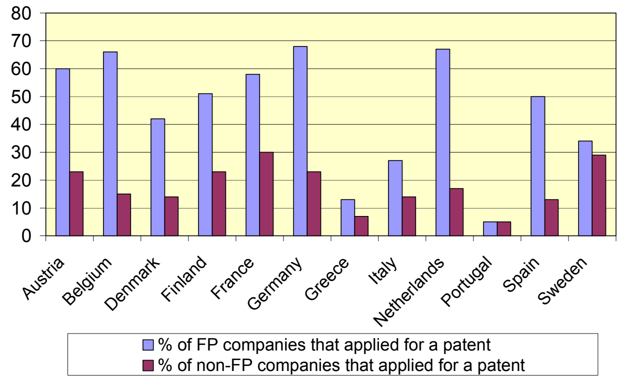
The production of patent applications or the definition of new standards is not the most important focus on INCO projects. Nevertheless, 13 projects signalled 18 patent applications and contributed to 55 new standards, while 38 projects developed 142 new pieces of software and 56 projects developed noteworthy industry contacts.

Figure 7a: FP Participants are more likely to produce product/process innovations



Source: DG Research, Eurostat Data: Eurostat
Note: Results here are for firms in the manufacturing sector

Figure 7b: FP Participants are more likely to patent



Source: DG Research, Eurostat Data: Eurostat
Note: Results here are for firms in the manufacturing sector

Available impact assessment data from the IST (Information Society Technologies) programme under FP5, and its predecessors in FP3 and FP4, point to a significant number of scientific and technological breakthroughs supported through FP funding, such as[139]: the development of the world's first fault-tolerant architecture for safety critical applications; in the area of Photonics, the world's smallest laser for telecom applications; the world's highest brightness single mode laser for long-haul telecom applications and medical treatment and the first Terahertz two-dimensional imaging of cancerous cells.

An in-depth analysis of the Third Community Innovation Survey (CIS-3) confirms that FPs have positive and substantial impacts on the innovative performance of European firms.[140] The results show that firms that participate in the FP, irrespective of their size, tend to be more innovative than those that do not participate. FP participating enterprises are also more likely to apply for patents than non-participants. In Germany, for example, FP funded firms make three times as many patent applications as non-participating firms. FP participating enterprises are also more likely to engage in innovation cooperation with other partners in the innovation system, such as other firms and universities. Although no causal links can be 'proven' by these results, they nevertheless provide a strong indication that public funding for research strengthens innovation performance (European Competitiveness Report 2004).[141]

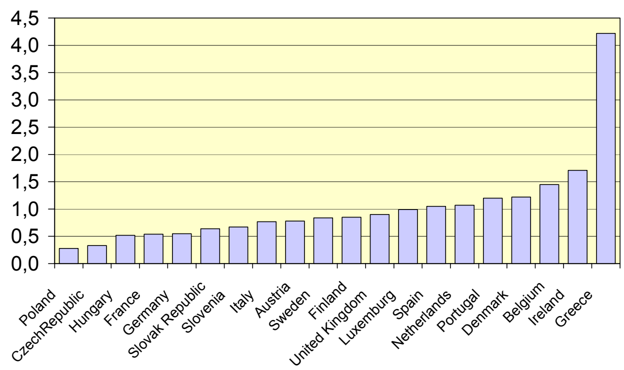
The cooperative research scheme CRAFT has an important impact on the competitiveness of small and medium-sized enterprises as shown by the resulting high number of commercial product and process innovations and new methods[142]. CRAFT projects not only have a positive impact on the participating SMEs, but also benefit a larger number of SMEs while the implementing the results. The qualitative benefits (e.g. access to knowledge of the partners, extension of technology and business networks) are considered very important. It deserves attention to take a closer look at the effects of participation modalities on research-intensive SMEs, in particular start-ups, as it could open up possibilities to increase the impact of the actions targeted at SMEs.

The FP generates substantial economic benefits for European firms

A wide range of ex-post evaluation studies show that as a result of FP participation firms are able to realise increased turnover and profitability, enhanced productivity, improved market shares, access to new markets, reorientation of a company's commercial strategy, enhanced competitiveness, enhanced reputation and image, and reduced commercial risks.

Results of econometric modelling indicate that the FP generates strong benefits for private industry in the EU. A recent study in the UK, commissioned by the Office for Science and Technology, used an econometric model developed at the OECD to predict FP effects on total factor productivity [FOOTNOTE 1]. It was found that FP "generates an estimated annual contribution to UK industrial output of over £ 3 billion, a manifold return on UK Framework activity in economic terms".[143]

Figure 8: High return to industry of FP5 -expressed as impact on total factor productivity (%)



Source: JRC, ISPRA

In the context of the present impact assessment, work was carried out by the Joint Research Centre in

Ispra to extend this approach to predict FP effects across all Member States for which data were available. The results seem to indicate significant effects on total factor productivity (Figure 8). For example, for Finland, first estimates suggest that 0.9% of the value added of industry per annum is attributable to funding from FP, while many Member States record even higher contributions. On average, it is estimated that € 1 of FP funding leads to a (long-term) increase in industry value added of between € 7 and € 14, according to the assumptions and parameters used. This increase will be spread over a number of years, because there is always a time lag before R&D spending produces its economic effects.

Of course, it is important to stress that econometrics is not an exact science, and that such results must be treated with a large degree of caution.

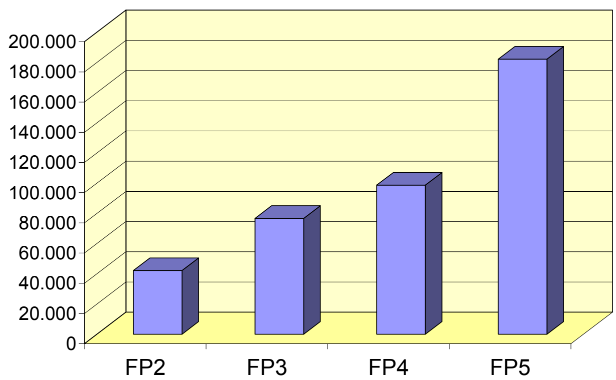
Structuring impacts on the European research and innovation system

The Community funding of research activities over the last few decades has not only impacted upon Europe's S&T performance. It has also had an important effect on the way in which Europe's research landscape is structured and organised. Barriers to pan-European cooperation have been broken down, and a greater coordination of national research efforts has been achieved.

Individual collaboration between researchers at project level

Collaboration has been at the heart of European research policy since the 1970s. Over the past two decades, the number of collaborative links resulting from EU funded collaborative research projects has increased dramatically to reach 180 thousand under FP5 (see figure 9).

Figure 9: Collaborative links (national and international) **established through FP funded shared-cost research projects**



Source: DG Research

Collaborative research projects stimulate trans-national partnerships, bringing together European scientific excellence, in order to achieve a critical mass not possible at national level. This involves sharing financial and human resources, and pooling complementary knowledge and expertise. A key aim of these actions is to promote the participation and interaction of different players - from academia, industry and public research laboratories at regional, national and European levels.

FP intervention in support of collaborative projects is having a number of effects in terms of restructuring research in the EU. One major impact is a decreasing fragmentation of the European research landscape.

Joining Forces through Networking: In this respect, a FP project on bioinformatics research – a dispersed scientific area within the EU - is illuminative: with the help of FP funding in the amount of € 12 million (2004-2009), 24 bioinformatics groups based in 14 countries throughout Europe joined forces within the 'BioSapiens' network of excellence. This network has created a 'European Virtual Research Institute for Genome Annotation' and a 'European School for Bioinformatics'. Such networks represent a specific form of collaboration. They allow researchers to gain access to new sources of knowledge and complementary expertise, to enhance their existing stock of knowledge, and to become familiar with new methods and tools. Another example is the "epigenome project", a network of excellence under FP6 in the field of epigenetics.[144] Understanding the epigenetic control strongly depends on sharing the knowledge on the different molecular pathways involved. This can only be approached via a coordinated European project involving not only exchange of knowledge and resources, but also through the work on different model organisms and the involvement of multidisciplinary expertises. And beyond the short term effect of enhancing scientific quality and the cross-disciplinarity of research, experience with FP5 and FP6 shows that networking establishes contacts which contribute to a long lasting integration of research efforts within Europe. Project partners increasingly keep their networks alive beyond the FP contract, continue the work and mobilise other funding sources for dissemination or spawning of activities.

Integrating S&T communities: In some areas, the European research programme has led to the creation of fully integrated scientific and technological communities. Europe leads the world in developing fusion, a safe and environmentally clean source of limitless energy. Research results strongly support the construction of the planned International Tokamak Experimental Reactor (ITER) which will demonstrate the scientific and technological feasibility of fusion power and give confidence that it should be possible to build Giga-watt fusion power stations. The European fusion programme is fully integrated at the European level and is jointly funded by the EU, the Member States and Associated Countries.

Developing Human Potential: Another crucial aspect of collaborative research is the development and training of human potential in R&D. Marie Curie Actions started as early as FP3, although not yet called so at the time. They comprise the scheme devoted to the training, mobility and career development of researchers. This scheme enables researchers to participate in top trans-national teams with high-level projects, and to benefit from training and knowledge sharing. By being exposed to different methods and approaches, and experimenting with new tools, researchers' know-how and knowledge are increased. This ultimately leads to better R&D results. Marie Curie actions also have a positive impact on the attractiveness of the EU for European and third country researchers by providing the means for brain circulation for skilled workforce and by openings for third country researchers in European research. In this respect, the pan-European Researchers' Mobility Portal (ERACAREERS, created in 2004) also contributes successfully to the realisation of the European researchers' employment market. It has established itself as a reference for the access to structured information on job opportunities in the R&D field within the Union.[145]

A steady increase of the budget for the Marie Curie actions for Human Resources and Mobility under the FPs is an expression of their key role within European R&D policy. FP6 activities in this area have benefited from nearly 10% (€ 1.6 billion) of the global FP's budget.[146] While the overall budget for FP6 has increased by 17% with respect to FP5, the budget for Human Resources and Mobility has been raised by nearly 70%. In addition, the high esteem of Marie Curie Actions within the scientific community is clearly demonstrated by the high numbers of applications: 4,300 proposals were submitted in 2003 and 7200 in 2004. Even the high oversubscription rate has not discouraged applicants. Indeed, despite already low success rates in 2003, applications for the Intra-European Individual Fellowship increased by 60% in its subsequent deadlines and those for the Research Training Networks doubled in the second deadline of 2003. Given the high satisfaction of stakeholders,[147] it is not surprising that there is a unanimous call for a substantial budget increase for Marie Curie Actions in FP7.

Intergovernmental cooperation at programme level

The FPs have been boosting trans-national research collaboration since the 1980s. But until FP6 this never went beyond cooperation between 'individual' actors at project level. FP6 and the ERA-NET scheme have brought about drastic change in this regard. While regular collaborative project funding continues in seven thematic priority areas, the ERA-NET scheme enables the combination of national research activities at programme level via a networking mechanism.[148]

Although first results will only be available in the spring of 2005, preliminary indications are that the ERA-NET scheme is a great success. Since the start of the scheme, interest has grown substantially, and themes as well as activities continue to increase. ERA-NET represents an important step towards the

durable integration of research activities at EU level, helping to bring together national research systems. In addition to achieving impacts such as improved evaluation schemes, better trained programme managers, more information on national best practices exchanged, less duplication and better use of research funds, the ERA-NET scheme is expected to foster the definition and implementation of joint programmes at EU level and the mutual opening of national programmes. The leverage effect of the ERA-Net scheme is large as it is estimated that an amount of research funds anywhere between € 20 million and hundreds of € million can be mobilised for an initial EU contribution of up to € 3 million per ERA-NET project. Joining efforts in a long term perspective helps to achieve the so urgently needed critical mass in Europe, and is the most convincing argument for the added value of ERA-NETs.

There is another novelty with regard to enhancing intergovernmental cooperation under FP6: Art. 169 of the Treaty has been applied for the first time under FP6 in clinical trials for developing countries with a budget of € 600 million (14 MS and Norway participate in the European and Development Countries Clinical Trial Partnership). It represents the stronger form of cooperation, for it implies a true integration of national programmes in a single programme and structure. After just one year of operation, it is too early to assess the impact of this article 169 application, but the prospects are promising. The main expected outcome is a better control over targeted poverty related diseases in Africa and other affected regions. This will reduce the social problems created by these plagues and decrease their long-term social costs.

Apart from the national level, the ERA-NET scheme is also open to regions. A direct coordination between regional programmes is realized in some of the ERA-NETs while in others national and regional programmes have been networked. Joint activities at regional level are thus expected to contribute to easier cross-border cooperation.

Interregional and international collaboration

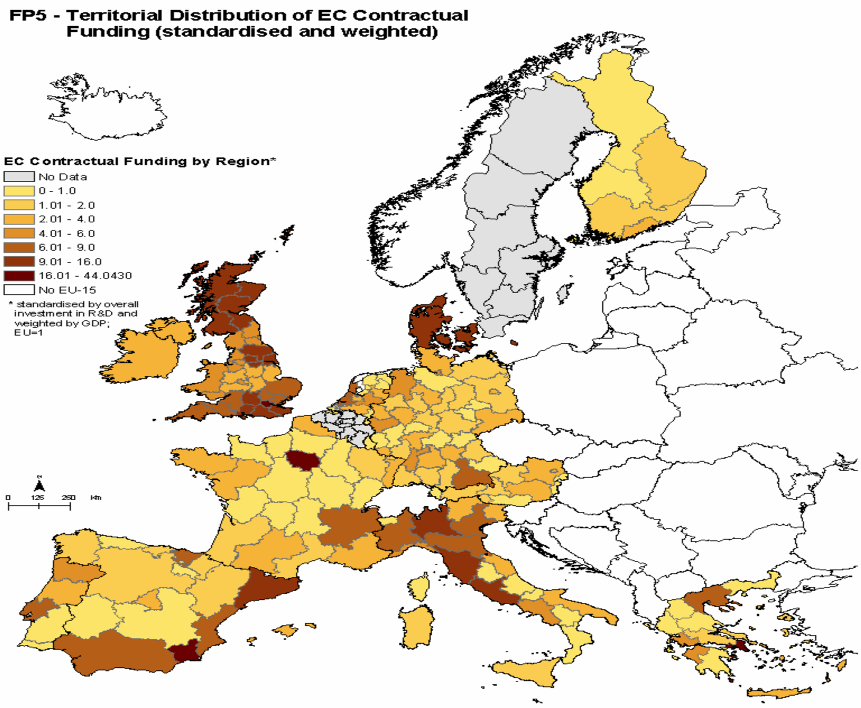
Although not conceived with a spatial focus in mind, the FPs clearly generate territorial effects. But what are these effects? Claims have been made that FPs are only about generating excellence at the detriment of fostering cohesion, or at least not actively contributing to territorial cohesion. It is said that pockets of highly successful research-based regions seem to benefit most from FP funding at the expense of struggling old-industrial, peripheral and agriculturally dominated areas. But is this the case? What are the spatial impacts of FP funding? How well in terms of scientific and economic performance do European regions that participate in FP fare?

A study analysing the participation of Europe's regions in FP 3, FP4 and FP5 (1990-2002) revealed several interesting results. Successive FPs supported excellent research without being detrimental to cohesion. These twin characteristics are first of all reflected in a concentration of funds in absolute terms in the main European research hotspots like for example London and the South East, Ile de France and Rhône-Alpes, the axis Stuttgart-Karlsruhe-Lower Bavaria, the Randstad, Greater Brussels Area, or the North of Italy.

Simultaneously, however, a large number of peripheral regions are allocated a greater share of European research funds relative to their overall R&D effort, the size of their economy, or their relative wealth, for example, Scotland in the UK, Catalonia and Murcia in Spain, and Steiermark in Austria. Successive FP programmes have created networks of research which are at the base of the diffusion of knowledge spill-overs which undoubtedly have eased the diffusion of knowledge from the centre to the periphery. One could say that the FPs take a catalyst role serving as a policy instrument to support the development of national and regional research capacities. A study undertaken in aeronautics research to identify the capacities of EU Member States indicates that "for most of the smaller aeronautics countries, and especially where there is national aeronautics research programme, the FP has come to be seen as the single most important policy instrument through which to support domestic capability".[149]

In addition to the regional impact, FP intervention also has an international dimension. Collaborative research funding via the FPs is far from being purely Eurocentric: the EU has been active in S&T cooperation with third country researchers and their institutions for more than two decades. In addition to the scientific results and outputs, there are good examples where international research collaborations have had tangible impact on the ground, not only in strengthening research capabilities in partner regions[150] but also in terms of uptake of results e.g. in product or process and policy developments.[151] Within peripheral countries European research activity is often, though not always, concentrated in those areas with the highest levels of GDP per capita and the greatest concentration of researchers and research activity as is the case in, for example, Helsinki, Lisbon, Madrid, Athens. Unless policy attention is devoted to this problem, this is likely to contribute to a widening gap between technologically networked and technologically isolated regions within the periphery. FP7 intends to reinforce the cohesive dimension of Community research policy and builds upon FP6 regional pilot activities.

Figure 10: A regional map of FP funding marrying scientific excellence and social cohesion



Source: DG Research

Data: DG Research, data treatment by LSE

Wider societal, environmental, and other impacts of Community research policy

Besides their effect on performance in terms of research and innovation, the FPs also have structuring effects on the European research and innovation system (including national and regional systems) – and indeed wider societal benefits as well. It should also be noted that, through these structuring effects, the FPs already have societal impacts extending beyond research. For instance, at the instigation of DG RTD, a number of CEOs from major European companies (including Airbus, Air liquide, EADS, HP, Rolls Royce, Schlumberger, and Siemens) have taken on the gender issue, recognising the benefits of encouraging woman scientists and engineers and making a public commitment to take steps to boost numbers and roles in their respective companies.[152]

At their most fundamental, FP outcomes consist of new knowledge (with 'the advancement of science' being of great value in itself). As outlined in chapter 3.2., the dissemination and exploitation of research results is one important argument for research at EU level. Dissemination is not necessary only to target the business sector so that it transforms the results into new products, processes and services, as has been proved by demonstration projects in previous FPs. An efficient use of relevant research results in policy development also helps the creation of an improved science-policy interface and interaction in support of the knowledge based policies. S&T advances can lead to economic benefits through enhanced innovation, competitiveness, and growth. The external evaluation study quoted earlier (which analysed some 1.200 projects of the BRITE-EURAM, Measurements and Testing, and Transport programmes completed in the period 1999-2001) calculated that the economic leverage effect for every € 1 000 million FP funding was € 1 100 million additional turnover generated, 2,700 new jobs created and 2,300 threatened jobs safeguarded. The increased wealth generated thanks to the R&D investment in turn provides the means to better face up to social and environmental issues. Alongside this indirect pathway, S&T advances can also have direct social and environmental impacts.

Wider social and environmental impacts: a steady gain still understated

Past EU Framework Programmes have devoted increasing – and increasingly visible – attention to social objectives. Since the launch of FP5 in particular – with its shift in emphasis from "knowledge increase" to "problem solving" – efforts have been made to enhance both the socio-economic contents of research and their recognition as such. The latter, however, still suffers from the lack of a comprehensive and systematic framework to monitor and measure socio-economic impacts, so that direct quantitative evidence of those impacts is scarce. The integration of the socio-economic dimension in all research areas has been forcefully pursued in FP5 and FP6. Ethics is an important special case. In general, the growing attention paid to the societal aspects of sciences in the FPs, in particular through the research programme on Social Sciences and Humanities and through actions in the area of Science and Society, is in itself a meaningful indicator of the consideration given to societal changes: research can thus increasingly help to establish the information base needed to solve social problems. Indeed, there are many European research initiatives for which the identification of lessons learnt and success stories is presented "by social impact area", thus allowing to ascertain that all major societal concerns have been recognised and addressed by EU research – through research that directly aims at the advancement of Social Sciences as well as through other, thematic, efforts.

Since FP5, each project's environmental targets and objectives must be detailed in the project proposal. This plays an important role in the evaluation and selection of projects to be funded. Nonetheless, the detail provided on these targets and objectives is seldom sufficient to allow for subsequent systematic monitoring and evaluation at the programme level. Therefore, it is difficult to quantitatively assess the environmental effects of these projects (e.g. in the form of reduced emissions, or decreased health risks, etc) at an aggregate level. Even so it is widely recognized that most RTD projects funded by the FP generate either directly or indirectly positive environmental impacts.[153]

In addition to projects focussing specifically on environmental research – which have led to beneficial breakthroughs in water management and in tackling global climate change for example – or on social research – which have tremendously advanced our understanding of social capital formation and indeed the 'knowledge based economy' for example – there are many initiatives that have valuable effects on both dimensions. The following also provides an opening towards the subsequent discussion of the policy impacts of R&D. The ongoing FP5/FP6 CIVITAS Initiative is playing a crucial and original role to improve the liveability of cities. With an integrated approach to transport and energy, it helps them to introduce and evaluate clean vehicle technologies. As part of its project, the city of Graz looked at the entire supply chain (well-to-wheel) and has come up with impressive results – it supplies 100% of the municipal bus fleet with biodiesel based on edible cooking oil that is collected from restaurants and households in the city. For the Hungarian city of Pécs, the involvement in CIVITAS is decisive for the development of its future transport policy – as a result it will develop its World Heritage zone into a car free zone. Toulouse in France will implement Europe's first "CNG at home" providing compressed natural gas to private vehicles. Large scale domestic production of alternative fuels in Slovenia has been initiated. And in Stockholm, the largest municipal vehicle fleet in the world will be fuelled through organic waste and sewage. These are some examples of initiatives balancing air quality, resource use, natural and cultural heritage, social and economic cohesion, and employment considerations – through research, development, and innovation.[154]

Supporting knowledge based policies: the impacts of R&D on the policy-making process

In addition to the economic, social and environmental dimensions, another important impact area is support to policies. In many cases, research serves as the source of the knowledge-base – and ideas – referred to in key policy documents.[155] Especially prominent in this regard is the JRC, whose role as a Community reference for EU policy in scientific and technological questions is epitomized by the increasing volume of legislation which is based on the work of (and which mentions) the JRC.[156] The FP projects themselves also provide many illuminating examples of such policy impact. Thus European BSE (Bovine Spongiform Encephalopathy) research, to which the Community contributed 90 million € in the period 1996-2003, provided the basis for close to 300 scientific opinions in support of almost 40 pieces of Community legislation in the fields of consumer protection, public health and risk management. This research was pro-active and explorative in nature, and thus enabled a rapid response to increased consumer food threats. In fact, the announcement in March 1996 of the links between BSE and the new variant Creutzfeld-Jacob Disease was the result of Community funded collaborative research. Even more recently, with the outbreak of the SARS epidemics, Community action proved extremely adaptive and prompt.

For the Environment and Sustainable Development Programme of FP5, a study showed that 70 FP5 projects were explicitly referred to in various EU policy documents. This provides an indication of the actual exploitation of research results for policy support.[157] A case in point is the European Climate Change Programme (ECCP) which explicitly recognised the role of research in the energy and environmental fields. The preparatory work that has led to the adoption of the Directive establishing a scheme for greenhouse gas emission allowance trading was supported by the results of the PRIMES and POLES models developed under previous FPs.[158]

Large scale problems posed by the transport sector, such as green house gas emissions, congestion, etc. can only find solutions if a European dimension is ensured. That means that European legislation to be proposed has to be well founded and therefore supported by the appropriate research activities. Strategic transport research results, for example, have been used by Member states, regional and local authorities, as well as infrastructure and transport operators. They have served to test ‘hybrid transport pricing’ in certain urban areas (PROGRESS, CUPID), introduce new approaches to urban mobility management and behavioural change (MOST, TAPESTRY), map the long-term challenges for public transport (VOYAGER), enrich university teaching and courses for decision-makers (PORTAL, TRUMP), etc. Major political initiatives, in fields like the European satellite navigation system Galileo and the Single Sky initiative have benefited from previous research. Research results, including assessment tools, technology tests and pilot projects have delivered input for the policies on the trans-European transport networks, the biofuels Directive, the proposed Directive for a River Information System and measures in the road safety programme.

The impact of energy research (EC and EURATOM) is at the forefront of the security of supply, climate change and competitiveness discussion – and research carried out in FP5 and FP6 is clearly contributing to meeting those policy objectives. The research includes short-to medium term as well as long-term objectives, which are only attainable in parallel with European energy policies and initiatives taken by Member States. During recent years, the EU and its Member States have accepted the tightest limitations of emissions among developed countries and they are in the process of putting in place a wide range of policies, from carbon taxes to energy consumption levies, from renewable energy obligations to energy efficiency obligations. At the same time, the gradual opening up to competition of electricity and gas markets and their integration across Europe and beyond, is fundamentally changing the context for investment and innovation. In this new and still evolving legislative and market framework, energy research is needed and must have a strong European and global dimension. Also environmental research provides valuable results for policy-making such as the POLES project and is useful for estimating the impact of Emission Trading Scheme and Post-Kyoto alternatives.

The case of Energy

Europe has developed world leadership in a number of other energy technologies, but this position is under severe threat from competition, particularly from the US and Japan. For example, Europe is the pioneer in developing and implementing modern renewable energy technologies, with beneficial environmental impacts. Western Europe, with its 16% of world energy consumption, accounted for 31% of the world increase in electricity generation from biomass between 1990 and 2000 and 79% of the increase in wind power. The EU power generation industry and its equipment manufacturers currently take about 50% of global world sales estimated to be worth €100 billion per year, but are especially vulnerable to fierce competition.

Despite intense competition between the major economic blocks, international collaboration is becoming an increasingly important element of energy research, which is not surprising given the global nature of the challenges and threats. Recent examples are the establishment of the International Partnership for the Hydrogen Economy (IPHE), the Carbon Sequestration Leadership Forum (CSLF), the Johannesburg Renewable Energy Coalition (JREC) and the international collaboration in the framework of the ITER project in fusion energy research.

The establishment of a fully integrated European fusion programme is considered as a model for the European Research Area (ERA). Success stories include the joint exploitation of the JET facilities; the strong co-ordination of fusion technology activities in the framework of the European Fusion Development Agreement (EFDA); the completion of the ITER final design through a joint international effort; and the increasing international role of the EU in fusion energy research. Strong and continuous long-term Community support, the co-ordination by Euratom and the human capital that has been developed by the Euratom Fusion Associations have been essential factors in enabling Europe to achieve an international leadership position in fusion energy research.

Nuclear power, which generates one-third of the EU's electricity consumed today, contributes to the independence and security of our energy supply and results in important reductions in CO2 emissions of over 500Mte of CO_2 per year. However, further research is required to ensure that high levels of safety are maintained, sustainable solutions to outstanding waste management issues are implemented and more efficient and even safer systems can be developed in the future. This will have important benefits for the EU's security of future energy supplies and protection of the environment, at the same time enabling EU industry to retain its world leader status in the increasingly competitive area of nuclear technology and services.

The case of the Common Fisheries Policy is particularly compelling, as scientific research provides the baseline for all Community action to manage and preserve fish stocks. One such example of direct impact of FP projects on Community action is the cumulative effect of a number of research projects on fish discards, which have provided the basis for a recent communication.[159] The importance of the 'support to policy' function of FP research is also marked in social sciences and humanities. The minimum wage policy of the EU, for instance, has been substantially affected by the work of the LoWER (Low Wage Employment in Europe) network. Since FP4, research and networks in ethics have supported pan-European debates and promoted a common understanding on issues related to the growth of new technologies, from nanotechnology to IT, from biotechnology to health sciences. These actions in turn pave the way for the development of EU polices related to the development and use of such technologies.

European R&D: "*Eppur si muove*" - *And yet it moves*

The words of Galileo, forefather of European science and technology, take on a distinct meaning here. In addition to the results of FP projects being used to support and improve public policies, the policy impact of R&D can also be seen in the increased visibility of the EU, in synergies between R&D and other Community actions, and in the positioning of the EU as an actor on the world scene.

The international role of the EU is notably strengthened through cooperation with developing, emerging and transition- economy countries and support to intergovernmental research cooperation initiatives. But it is also reinforced through Specific Programmes and projects (see the box on RTD in the field of energy, above, for example).

International S&T cooperation with third countries (INCO) has evolved around the concept of sustainable development and the idea that poverty and social marginalisation can be overcome successfully by investing in human and institutional resources. INCO has played an important role in the EU Framework Programmes since 1983. The INCO programme is based on dialogue and promotes the development of long-term durable research partnerships – with four main regions: Latin America, Asia, and Africa; Mediterranean countries; Western Balkans; NIS. For instance, in CEEC and NIS countries an indirect socio-economic impact can be observed concerning scientific job creation potential, substitution of imported goods, improved food quality and environmental protection from rapid industrialization and urbanisation. In most of the Asian and African INCO funded projects concerning agriculture, food, and health, socio-economic impact is evident on parameters such as improvement in farmer incomes, gender equality, public health, education, and employment; the impact was also substantial in areas such as protection against erosion, conservation of natural resources and training and profession improvement.

Many industrialised countries outside Europe participate in the FPs. Some have already signed S&T agreements with the EU, such as the USA, Canada, Israel, and Australia. For instance, an ongoing study has been commissioned by the Australian Government Department of Education, Science and Training (DEST) on Australian science and technology co-operation with Europe. It already indicates that Australian researchers want to work with Europe because it is seen as a site of leading-edge collaboration and that there is a large potential for expanded collaboration. The benefits of cooperation are mutual (and particularly salient in the situations described in section 2 of chapter 3).

The intergovernmental research cooperation initiatives (EUREKA, COST, INTAS) of the FPs spend only a small part of funding (in relative terms) – and yet generate or 'catalyse' a much more considerable investment:

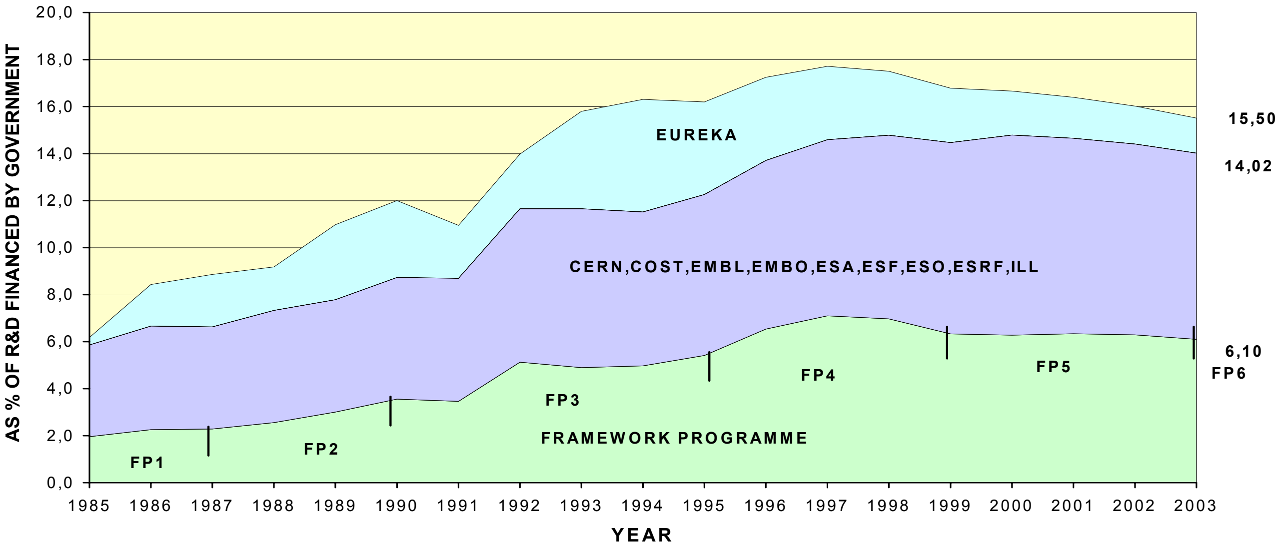
➔ EUREKA: € 1.2 million for 2003-2006, generates about € 850 million each year

➔ COST: € 50-80 million for 2003-2006, generates about € 1.500 million each year

EUREKA, COST, INTAS and the intergovernmental research performing organisations have managed to increase the impact and the visibility of European research worldwide. Community coordination has allowed for the integration of these organisations in the efforts to develop the ERA, and has helped foster their contributions to building ERA.

For example, EUREKA has stimulated international cooperation in firms (especially SMEs), has developed through its programmes a number of successful products, and has thus increased overall European industrial competitiveness. Currently, EUREKA launches around 165 new projects worth about € 400 million each year. In addition, as part of its clusters scheme, it launches about 14 sub-projects per year, worth around € 450 million. Ongoing projects involve around 8,000 scientists and engineers. With its large industrial participation, EUREKA makes a particularly important contribution to the 3% Barcelona objective. The most visible cooperation measures are the so-called Joint Technical Groups, set up in April 2004, to improve coverage of R&D areas between EUREKA and the FP. Looking beyond the FP, and as a concluding remark, it should be noted that the relative importance of European public cooperative research has steadily increased with respect to R&D financed by Member States governments. Indeed, as shown in Figure 11, it has grown from 6% in 1985 to 15.5% in 2003.[160] This can be seen as a shift of resources towards a more efficient way of implementing R&D. Yet it can only be thoroughly satisfactory if it is coupled with an increase in overall R&D intensity in the EU.

Figure 11: Cooperative research as a percentage of government R&D expenditure in EU-15 and EFTA countries



Source: DG Research

Section 3: Towards FP7: the views of the stakeholders

Throughout the history of the FP, great importance has been attached to consulting stakeholders in order to improve implementation and help in the design of the next FP. In the preparation of FP7, the views of the scientific community, industry and other interested parties have been represented through a range of specific consultations – alongside the more institutional fora. Indeed, the preparation of the FP7 proposal benefited from extensive inputs from stakeholders, making use of new opportunities to organise online consultations through the internet.

Who was consulted?

Consultations were launched on the basis of the Communication “Science and Technology, the key to Europe’s future – Guidelines for future European policy to support research” of June 2004.[161] To further promote and inform the debate, a number of additional working documents were made available on the internet during the Autumn of 2004, for example on Technology Platforms and the principles of a European Research Council.

The consultations aimed to engage the broad range of stakeholders who are involved in research activities, research policies, and the use of research results, including: public administrations, research institutes, universities, large companies, SMEs, associations, international organisations and interested individuals.

Within the Institutions, the Guidelines were debated in the Council (in particular the September and November Competitiveness Councils in 2004), the Parliament (ITRE Committee), the Committee of Regions and the European Economic and Social Committee. To allow all individuals and organisations with an interest in European research to provide their views, the Commission launched an online questionnaire on the Guidelines from July to October 2004. For individuals, organisations and associations who wished to provide more detailed views, the submission of position papers and other written contributions was facilitated through the establishment of a website. Specific contributions were provided by EURAB.

In addition, the Commission organised a number of more focused consultations to identify those areas of research to be funded under FP7. To aid this process, a website was established providing links to all relevant consultations and setting out criteria (contribution to EU policy objectives; EU research potential; and EU added value) being used by the Commission to identify which areas of research would be included in the FP7 proposal.[162] Stakeholders were consulted in each area of research through expert groups, events and targeted consultations. Internet based consultations were undertaken in the areas of research on information and communication technologies, nanotechnology, Science and Technology Foresight and the social sciences and humanities. In addition, an open consultation to receive contributions relating to any area of research or consolidated contributions took place from 8 November to 31 December 2004.

A wide and extensive range of other meetings, expert groups and events were organised to gather advice on the design of the Commission’s proposal for FP7. For example, an expert group was appointed in the summer of 2004 to advise the Commission on its preparations for a new mechanism to fund basic research; the Commission organised separate stakeholder conferences on SMEs and human resources in December 2004, and a major conference was held under the Dutch presidency on “Investing in Research and Innovation” in October 2004. Finally a large number of meetings were held at national level on issues such as technology platforms.

Main results of the consultation

The Commission received a very high level of response to the consultations which can be said to represent a good indication of the views of the research community and research users. A total of 1727 responses were received to the consultation on the Guidelines, of which just over 30% were from individuals, 26% from universities and 8.3% from SMEs and a further 6.7% from larger companies. In terms of country balance, there was generally a good response from many Member States (e.g. over 100 responses from Germany, the UK, Italy, Belgium, France and Spain). However, relatively few responses came in particular from some of the new Member States.

The consultation on the Guidelines asked respondents to rank the importance of the objectives set out in the Communication, to indicate their level of agreement with the text of the Communication, to indicate their view on the potential impact of the proposals, and to provide additional comments.

A very clear message is the high degree of support for the Commission's proposals. As a result, over 97% of respondents agree or mostly agree that support for research at the European level should be strengthened (only 1.4% disagree or mostly disagree).

Regarding the impact of strengthened European level research support:

- Over 95% agreed or mostly agreed that this would have an important impact (1% disagreed or mostly disagreed);
- Over 92% agreed or mostly agreed that this would contribute significantly to Europe's competitiveness, social welfare and sustainability (only 1.6% disagreed or mostly disagreed).

Concerning the 6 axes presented in the Guidelines: Between 81 and 96% rate them as 'important' or 'very important'. The highest level of support is given to the orientations for human resources and then for collaborative research. In general, the level for support for the approach proposed by the Commission in the Communication text is also very high. Finally the vast majority of respondents considered that the impact of these orientations would be as indicated in table 2 in the executive summary.

The consultation results also demonstrate strong support (88% or more considering the aspect to be 'important' or 'very important') for:

- Improving science and society relations[163],
- Supporting innovation,
- Supporting research in SMEs and for their benefit,
- Identifying topics of major European interest and supporting the Union's policy objectives.

Stakeholders made a large number of more detailed comments about the guidelines. The most common concerns were for improved procedures and less paperwork in the implementation of the Framework Programme, and the need for more specific information on the various proposals, in particular the European Research Council and European Technology Initiatives. An analysis of the results of the stakeholder consultation was made available on the internet in December 2004.[164]

Further to the online questionnaire, the Commission has received over 150 position papers and other written documents in response to the Guidelines. These include contributions from many of the leading research organisations and research users (including industry). The contributions generally reflect the views put forward in the online consultation and confirm the broad support for the guidelines set out by the Commission and the need to strengthen European support for research.

Some 1800 responses were received to the general consultation on research themes for FP7. In addition, many hundreds of responses were sent to the consultations in specific areas of research. The research agendas developed by Technology Platforms also provided a valuable contribution to identifying priority areas for future FP support. These inputs were used in formulating the content of the high level themes set out in the FP7 proposal. They will be further analysed in preparing the content of the Specific Programmes.

In addition to the consultations and inputs from direct stakeholders, the opinions of the European Institutions have been taken into account in the FP7 proposal. The presidency conclusions of the Competitiveness Council of November 2004 urged the Commission to present the FP7 proposal on the basis of the Guidelines, taking into account the results of the policy debate and prior consultations. In addition, many Member States and some third countries have provided more detailed position papers. Particular points stressed by the Council and national position papers include: collaborative research should remain a core of the FP and provide strong continuity with FP6; strong support from a large majority of Member States for basic research and the creation of a European Research Council; and the need for a strengthened European strategy in the field of research infrastructures and for a better coordination of national research programmes. Special emphasis was put on horizontal aspects such as the European added value, the promotion of excellence of European research and the need for simplification of administrative procedures.

Following the discussion in the Industry and Research Committee (ITRE) and other relevant Committees, the European Parliament is expected to strongly support the need for a strengthened scale and scope of the FP7 proposal, including the doubling of the budget and the establishment of a European Research Council. In addition the opinion is expected to emphasise the need for: further rationalisation, simplification as well as increased participation of SMEs, improving human resources (particularly through encouraging women and young people to enter research careers); and synchronising the duration of the Framework Programme with that of the Financial Perspectives.

The Committee of the Regions and the European Economic and Social Committee adopted their opinions on 17 November 2004 and 15 December 2004 respectively. Both of these advisory bodies strongly supported the development of the FP7 proposal based on the Commission's guidelines.

The European Research Advisory Board made a number of specific contributions to the debate. Not less than 18 sets of recommendations were addressed to the Commission from the creation of EURAB in July 2001 up to June 2004, covering various aspects of research policy, from general views on the future of the European Research areas down to specific comments on the Descartes Prize, and including on critical issues such as the European Research Council or the Technology Platforms.[165]

On 10 March 2005, the European Parliament adopted by overwhelming majority a report on the future of EU research policy, giving support to the broad ideas presented in the Commission's communication 'Science and technology - Guidelines for future European Union policy to support research'. By doing so, the EP backed the European Commission in its aspiration to attribute primary importance to research and innovation in its proposals for the EU's new financial perspectives and supported the doubling of the budget earmarked for the seventh Framework Programme. Like the European Commission, the EP views increasing investment in research both at EU and national level as a crucial element for economic growth. The establishment of a European Research Area (ERA) will not be possible without a significant budgetary increase, claims the report, which subsequently 'calls for the same determination that was manifested in pursuit of the single market and monetary union to be applied by all Member States and EU institutions to building the ERA.'[166]

Changes following the consultation

The results of the consultation have been used extensively in preparing the FP7 proposals. Particular examples include: the significant budget increases for researcher mobility and SME specific actions respond to the strong support from stakeholders and their concerns about oversubscription in these areas; the concerns regarding the administrative burdens of participating in the Framework Programme are taken into account in the simplification measures proposed; and a large number of the research topics (including those proposed by Technology Platforms) are covered in the proposed thematic priorities – further consideration at a more detailed level will be made in preparing the Specific Programmes.

Chapter 5: Assessing the various policy options

The proposal for the 7th Framework Programme should build upon past experience, but it should also respond to three key factors driving EU RTD policy. It should be tailored to European S&T needs. It should be responsive to stakeholders' requests for new actions in the fields of industrial and basic research. Finally, it should respond to stakeholders' demands for a more user-friendly and outcome-based FP. The first part of the first section of this chapter (II. 5.1.) provides more detail on these three key driving factors.

Following this, three basic policy options are considered for an assessment of the extent to which they take account of these key driving factors. The first basic policy option presented consists of an admittedly hypothetical and academic *'no framework programme'* option. Under this option, it is assumed that the FP is discontinued and that EU Member States either to a larger or smaller extent compensate for this. Despite its theoretical nature (the FP is a Treaty obligation), the analysis of such an option allows for a much better assessment of the true value added of the FP. The second basic policy option is *'business-as-usual'*, i.e. an extension of the FP6 model. And the third basic policy option consists of the *FP7 proposal*, which skilfully mixes continuity and change.

The second and third sections of the chapter (II. 5.2. and 5.3.) focus on the actual impact assessment of the proposed actions in FP7. First, impacts are assessed at the level of the proposed Specific Programmes. Under each heading, a brief recall is made of the challenge faced, followed by a short description of the proposed action, and an assessment of the impact of the proposed action as compared to doing nothing or continuing in line with FP6.

The third section of this chapter examines the aggregate economic, social and environmental impacts of the FP, and assesses the contribution of each basic policy option (as well as of a number of sub-options) to the achievement of the Lisbon, Barcelona and other Community objectives.

It should also be mentioned that a key input informing the development of options for FP7 was the 5 Year Assessment of the European Union Research Framework Programmes 1999 – 2003. This major exercise, conducted by an expert panel chaired by Dr Erkki Ormala, reported in December 2004. The legal base of the Framework Programme requires such a 5 Year Assessment before any new proposals for the 7th Framework Programme are put forward. The global Framework Programme 5 year Assessment was re-inforced by the findings of a separate panel convened to assess the FP Information Society Technologies R&D over the same period and chaired by Professor J M Gago.

Both reports strongly endorse the role of the EU Framework programmes in strengthening the European knowledge base and European competitiveness. In addition to these evaluation reports, the FP7 proposal takes account of numerous studies (foresight, indicators, thematic area reports, etc.) as well as consultations with experts and stakeholders.

Section 1: What are the options for European RTD policy?

Key factors driving EU RTD policy

The structure and content of FP7 have been conceived and designed so as best to respond to three key factors driving EU policy on Research, Technological development and Demonstration (RTD):

1 – A structure tailored to European S&T needs

A crucial issue in designing the next FP is the most appropriate structure for the programme. Of course, European level programming is different from the preparation of programmes in the Member States because European added value is a dominant driving theme. EU programmes must also take account of the diversity of research players in Europe, each with their own specific needs, be it different institutions (universities, SMEs etc.), different industry sectors, or indeed 25 different countries each with their own S&T systems and policy priorities. A workable consensus therefore has to be found on a form of programme which responds effectively to these sometimes competing needs, and which presents a strong added value.

The next FP should also be a vehicle for addressing a number of key policy challenges at EU level. Given the emphasis put by the new Commission on the Lisbon agenda and its objectives, the FP needed to be designed as an instrument that actively contributes to boosting EU growth and competitiveness. This aspect also needs to be combined with the promotion of sustainable development and social cohesion.

It was also important to develop the structure of the FP so as to better address inter-disciplinary research and the increasing convergence of fields such as ICT, biotechnology and nanotechnology. It should be clear to applicants where they should apply if they have inter-disciplinary projects.

A further consideration was to concentrate FP7 funding on a small number of key S&T areas and to avoid as far as possible fragmentation of effort. As shown earlier (II. 4.1.), the trend in previous FPs has been towards a proliferation of S&T priorities and a resulting dispersion of funding.

The structure of the new FP needed to take all these aspects into account. Here, a design choice had to be made between three different approaches to S&T policy intervention:

- ***The generic (horizontal) approach:*** This is essentially a bottom-up programming model driven by the researchers themselves. Under this model, support schemes are established – for instance, for basic research or applied research – but no specific horizontal priorities (e.g. female or young researchers, SMEs, cooperation etc.) or vertical priorities (e.g. ICT, nanotechnology, biotechnology etc.) are identified.[167]

- ***The problem-oriented (horizontal) approach:*** Under this approach, support schemes are devised in a more targeted manner to address specific horizontal problems in the research and innovation system. They focus on either specific actors (e.g. female or young researchers, universities and public research institutions, SMEs etc.), or on specific problems affecting the innovation system (lack of collaboration between universities, among industry, between universities and industries).

- ***The pro-active (vertical) approach:*** This approach identifies clear priority S&T fields or industrial sectors (e.g. ICT, biotechnology, nanotechnology, transport technologies, energy etc.), allowing policy-makers to target funds on S&T fields of future importance. The majority of the EU Member States (Austria, the United Kingdom, the Netherlands, Spain, Hungary, etc.) as well as other countries follow this approach (USA, Japan, Korea, Canada, etc.)[168].

One can categorize most research programmes at national level under one of these three broad headings, and each approach has its advantages and disadvantages (see table 2). Given the diversity of research actors and challenges FP7 addresses, its structure has been based on a mixture of these three approaches.

2 – Respond to stakeholders' demands for new actions for industrial and basic research

A second key factor influencing the design of FP7 was the demand from stakeholders for new types of action. As seen earlier, the many comments received on the Communication *"Science and technology, the key to Europe's future"* indicated major support for a new action in the field of basic research, and for more bottom-up concerted support to EU industry (see II. 4.4.).

European industries urgently need to innovate and introduce new products and processes to raise productivity. They need to become more knowledge-intensive and high-tech. Efforts into that direction necessarily need to be research-based. The implementation of large-scale, strategic research agendas is required to help European industries improve their competitiveness. The execution of such agendas assumes the European-wide mobilisation of most if not all actors within a particular industry as well as the sustained allocation of massive funding.

At the same time, there is a strong demand from stakeholders to further increase the quality of

European basic research by revolutionizing its funding mechanism, and in particular by scaling up the competition for research funding to European level. Increased competition should drive up the quality of research proposals, leading to higher levels of excellence in Europe's basic research.

Table 2: Advantages and disadvantages of the three approaches to S&T policy intervention

	The three approaches		
	Generic/horizontal S&T approach	**Problem-oriented/ horizontal S&T approach**	**Pro-active/vertical S&T approach**
Advantages	* A bottom-up approach driven by the researchers themselves * Policy-makers do not have the problem of choosing which fields of S&T to finance * It is more in line with a generic technology policy * It broadens and thus intensifies the competition for research funds	* Top-down horizontal priorities without any limitation in terms of sectors or S&T fields * It allows policy-makers to target funds on specific problems (cooperation, SMEs, young researchers, mobility….) * Compatible with competition policy and horizontal industrial policy * High restructuring effect and problem solving approach	* A top-down approach driven by policy makers * It allows policy-makers to target funds on S&T fields of future importance * It enables a better articulation of S&T policy with other structural policies * High restructuring and specialisation effect
Disadvantages	* No restructuring effect (continuity of the existing S&T structure) * No guarantee that new or emerging fields could be adequately supported * It is not certain that broader societal, industrial or environment objectives will be taken into account * Fragmentation risk of public funding * It is difficult to defend politically and to manage by different entities	* Possible dispersion of public money in different sectors and or domains * How to make priorities between different problems * No public support for the winners or for the sectors where there is no problems	* It can be difficult for policy-makers to predict with certainty the fields of importance for the future * There is the possibility of conflict with competition rules * Danger of proliferation of objectives * Danger of overinvestment in some sectors or S&T fields

3 – Respond to stakeholders' demands for a more user-friendly and outcome-based FP

Finally, the organisation of FP7 should be responsive to stakeholders' calls for the streamlining of administrative procedures. Specific concerns regarding FP6 implementation have been raised by a range of actors during the stakeholder consultation, and this issue has also been addressed in the Marimon and 5-Year Assessment reports.

Firstly, FP7 must find the right balance between accountability and accessibility. One the one hand, a public expenditure programme must involve an adequate degree of control and monitoring. On the other hand, it is important to reduce barriers to application and enhance the attractiveness of the FP. Its instruments must be easily understandable, with clear objectives. Information requirements should not be such as to discourage large numbers of researchers from preparing a proposal. Efforts should be made to reduce the length of time required to successfully negotiate a contract. The reporting requirements once the project gets underway, and at its end, need to be lighter.

Secondly, given the renewed focus on the Lisbon objectives, FP7 should be designed so as to maximize the impact of RTD activities. Measures ensuring output and impact should be integrated into programme design. Monitoring indicators should be defined and a comprehensive data capturing and analysis system developed to monitor progress towards the realisation of the Lisbon, Barcelona and other European objectives.

Three basic policy options

In order to facilitate the analysis of the contribution made by FP7 to the achievement of the Lisbon, Barcelona and other European objectives, three policy options are considered: discontinuation of the Framework Programme ("*do nothing*"), no-change ("*business as usual*"), and a new FP7 with different priorities, budget and instruments.

The "do-nothing" option serves to demonstrate whether without EU intervention it is possible to reach the same objectives. It relates to a policy of no financial intervention at EU level in the field of RTD (discontinuation of FP). This is a hypothetical option since the Treaty contains specific obligations to carry out Community research. However, it is nonetheless an essential benchmark against which to demonstrate the full added value of the FP7 proposal (option 3), which cannot be deduced simply from its marginal effect in relation to the status quo (option 2).

The "business as usual" option would mean launching FP7 as a continuation of FP6, with the same budget allocations, the same objectives, the same institutional actors, the same research priorities etc. The premise underlying this option is that FP6 can adequately address the major challenges facing Europe in the coming years without introducing any major changes to its size, structure and organization. This option also responds most clearly to the important concerns about continuity and stability of EU research actions.

The third policy option is a restructured FP, resourced with a substantially higher budget and designed so as to better respond to the targets set at Lisbon. It starts from the observation that circumstances have changed significantly since the launching of FP6, and proposes an action that builds upon the accomplishments of FP6, but is characterised by a new scale and a new scope. Within this option further 'sub-options' were identified and certain important choices had to be made, and these are also analysed.

The proposed FP7 combines incremental change with continuity. The continuity of FP7 compared with FP6 lies in the thematic priorities, which will be largely the same as under FP6, and the instruments, many of which will be the same as under FP6.

The first major change under the proposed FP7 as compared to FP6 lies in the programme's strategic orientation. Where FP6 was conceived as an instrument to achieve ERA, FP7 will be bigger and structured differently so as to better respond to the Lisbon targets. The ERA concept is still important, and efforts will be continued under FP7 to make ERA a reality. However, circumstances have changed significantly since the launching of FP6, and FP7 is conceived as a response to the new challenges. In particular, as indicated in the Kok report, progress towards Lisbon has been too slow, and in spite of the initial impetus induced by the European Research Area (ERA), there is a need to reinvigorate European research effort. FP7 therefore constitutes a response to this urgent need for reinvented Community action in the field of S&T. It proposes an action that builds upon the accomplishments of FP6, but is characterised by a new scale and a new scope.

Linked to the need to face these challenges is the second major change: It involves a substantial increase in Community investment in research. The budgets of the current EU Member States are under pressure due to the changed economic climate and they cannot be expected to increase their investment in research in the short term. Furthermore, the ten new Member States have rather low levels of investment in research.

Thirdly, FP7 will be organised according to four basic programmes:

- **People**: To build on past experience, the Marie Curie action will evolve to focus better on key aspects of skills and career development, while strengthening the structuring effort and the link with national systems.

- **Ideas**: To support "investigator-driven research" in all scientific and technological fields, including social sciences and humanities.

- **Cooperation**: To support the whole range of research activities in cooperation on topics linked with the major EU policy objectives, from small projects and networks to large scale coordination of national research programmes, on topics linked with the major EU policy objectives including the development of a powerful knowledge-based European industry.

- **Capacities**: This will include support for research infrastructures, both existing and new; development of "regional research driven clusters" associating closely universities, research centres and enterprises; support for the full development of the potential of excellence existing in the "Convergence" regions of the EU; research for the benefit of SMEs; reflection, debate, research and action on "Science in Society" issues and in support to the development of research policies considered in this context; and specific activities of international co-operation.

For reasons of logic and simplicity, these four dimensions will be subjects of as many Specific Programmes. The programme 'Cooperation' will be organised in a number of sub-programmes which will be operationally autonomous as far as is permitted by the need to ensure coherence and consistency.

In order to create critical masses of resources and to avoid dispersion in the context of a limited envelope, FP6 concentrated strongly on a selected number of themes and topics. The activities identified are: Health; Food, agriculture and biotechnology; Information and communication technologies; Nanosciences, nanotechnologies, materials and new production technologies; Energy; Environment and climate change; Transport; Socio-economic sciences and the humanities; and Security and space research.

In FP6, the Thematic Priorities were complemented by the NEST activity ("New and emerging S&T"), with the aim to stimulate creative, visionary and anticipatory lying outside or cutting across the domains covered by the Thematic Priorities. The rationale for collaborative activities of this type remains throughout FP7: it remains necessary to foster a creative, entrepreneurial spirit in European research, to provide rewards for "high risk / high impact" science, to vigorously promote multi-disciplinarity. Therefore, each area of collaborative research will include an element of NEST-like activities.

The fourth major change is that FP7 will be more user-friendly and output oriented by setting clear and measurable objectives, also in the fields of dissemination and exploitation of research results, and monitoring progress towards their achievement. It would also aim to improve the functioning of the framework programme by reviewing and simplifying the financial and administrative provisions in the light of current experience.

Section 2: What are the impacts of the various policy options?

Specific Programme 1: People

Abundant and highly trained researchers are a necessary condition to advance science and to underpin innovation, as well as an important factor to attract and sustain investments in research. In order to make Europe more attractive to the best researchers it is needed to maximise, quantitatively and qualitatively, the human potential in research and development in Europe.

The FP7 proposal would consist of building upon past experience with human resources and mobility and thereby ensure the necessary continuity. Five coherent lines of action will be focused upon (see the proposal for details): the initial training of researchers; life-long training and career development; support to longer-term co-operation programmes between organisations from academia and industry; actions to address the extra-European dimension; and policy actions to support the emergence of a genuine European labour market for researchers. Compared to FP6, the budget for actions in the field of would triple.

As a result of the different actions envisaged in the field of human resources under FP7, it can be expected that more research can be carried out in Europe and that the research will generally be of higher quality, more inter-disciplinary oriented, and where appropriate take better into account the industry orientation. This will be the result of actions with a structuring effect throughout Europe on the organisation, performance and quality of research training, researchers' career development, thereby making scientific careers more attractive for European citizens (in particular women), making Europe more attractive to the best foreign researchers, increasing levels and diversification of the skills and competence of individual researchers, introducing sustainable pathways between academia and industry (including SMEs) and between disciplines, unlocking the potential and thereby improving the capabilities of scientific institutions (in particular in the Convergence Regions of the EU and in the Candidate Countries) and networking individual researchers and scientific institutions.

Making Europe more attractive for foreign researchers, and making scientific careers more attractive for European citizens, will help contribute to the achievement of the Barcelona 3 percent objective, for the realisation of which an estimated 700 000 additional researchers and an increase from 6 researchers per 1000 labour force to 8 are needed.

The attractiveness of science careers is essentially limited by the number of research positions created at universities, public research institutions and industry, on which these actions will have no impact. The competition at the global level for skilled human resources will continue to increase. It is therefore important that in parallel with the actions to make Europe more attractive to the best researchers, Europe provides more investment in research.

Specific Programme 2: Ideas

Stakeholders - be it decision-making institutions like the Council and the EP, the Member States in their position papers, or individuals in the online consultation - share the conviction that the quality of European basic research urgently needs to be further improved. Previous chapters in this report have clearly demonstrated how innovation is crucially dependent on high-quality basic research. Societal returns on investment in basic research are high as most products and processes leading to commercial success or improvements in the quality of life result from basic research. As Europe is facing an increasingly competitive world and the problem of ageing, and in danger of becoming less attractive to companies as a place to carry out research or to researchers as a place to engage in a scientific career, the achievement of the Lisbon agenda becomes more and more urgent. Faster and more value-added innovation is required, which will result in more economic growth, more and better jobs, higher productivity and a better competitive position in international markets. As outlined earlier, European funding for basic research is limited and fragmented. A careful analysis of indicators also shows that the quality of European basic research can be further improved.

At present, the competition for basic research funding between individual research teams is mainly organised within the context of closed national research systems. In most countries, however, the number of potential applicants in highly specialised fields of science that are critical to Europe's future competitiveness is so small as to render competition essentially meaningless. This has deleterious effects on the quality of the applications submitted and the proposed research. A trend has recently emerged towards countering this familiar problem of fragmentation and opening up national research systems to applications by individual research teams from other countries. But implementation is slow and not systematic. Some basic research is also already funded at the European level. But that is mainly through collaborative research schemes that through their obligation to include research teams from a minimum number of different member states serve slightly different objectives.

Ideas[169]

To capture the changing nature of research, particularly as it pertains to the proposals for an ERC (e.g. the Mayor report, various documents by the Commission and others) we have adopted the new term, **'Ideas'** – also referred to as frontier research. This choice of wording reflects a number of essential characteristics:

- First, and most importantly, frontier research is at the very forefront of developing new knowledge and understanding, of making fundamental discoveries and quantum leaps in our theoretical understanding, of achieving the revolutionary advances that may be rewarded with Nobel Prizes and other international awards.
- Second, frontier research is an intrinsically risky endeavour. In the new and most exciting research areas, it is often not yet clear which approach or trajectory is ultimately likely to prove most fruitful for the development of the field. There is, as yet, no established dominant paradigm (as there is, say, in many areas of physics or chemistry). In Kuhn's terms, the research is 'pre-paradigmatic'. Consequently, it is highly risky.
- Third, frontier research is characterised by an absence of disciplinary boundaries. Whereas much basic research is carried out within established scientific disciplines, the most exciting areas of frontier research require multi-, inter- or trans-disciplinary research, bringing together researchers from different disciplinary backgrounds, with different theoretical and conceptual approaches, different techniques, methodologies and instrumentation, perhaps even different goals and motivations.
- Fourth, because the mix of knowledge and skills required for this kind of research is so wide-ranging, it often cannot be found within single nations, especially the smaller ones. Frontier research is therefore characterised, even more so than 'basic research', by an absence of national borders.

The key to increasing the quality of European basic research lies in revolutionising its funding mechanism. Earlier chapters in this report have demonstrated the degree to which, because of the existence of various market failures, basic research is generally publicly funded. Adapting the funding mechanism thus has the potential to positively affect the quality of basic research. The proposed option consists of introducing to the field of basic research the added value of organising the competition for funding between individual research teams at the European level. The positive effects of competition in R&D are well demonstrated.[170] It will introduce a European, continental-scale funding competition to bring out the best research and drive up levels of excellence. This will be accomplished through the creation of a European Research Council which will be guided by the following principles:

- *Investigator-driven:* The research proposed for funding by the ERC will be bottom-up or investigator-driven.

- *Autonomous:* The ERC will be scientifically autonomous in order to have credibility with the scientific community. It will decide autonomously about evaluation procedures etc.

- *Accountable:* The ERC must be seen as legitimate, properly accountable and efficient.

By improving the quality of European basic research, the positive social and economic benefits generated by basic research can be further increased. Scaling up the competition for research funding to European level will increase competition and drive up the quality of research proposals, leading to higher levels of excellence in Europe's basic research. This will result in a better and enlarged knowledge base for European enterprises on which the innovation of products and process can be based. This will have direct economic, societal and environmental benefits.

The creation of the ERC and the introduction of a European-level funding scheme would have important levelling-up effects as incentives will be provided all over Europe to increase institutional and researcher capabilities, produce better research proposals, and carry out higher-level research.

The ERC would also have important structuring effects. The visibility of basic research funded at European level will make it easier for actors in the European innovation system to pick up on the knowledge resulting from that research and thus reduce information-related market failures and improve the European knowledge market. At the same time, the higher quality and increased visibility of European basic research will make Europe a more attractive place to companies to carry out research in and to individual researchers to engage in scientific careers.

One possible risk associated with the creation of the ERC is that free-rider problems can emerge and that EU member states will reduce their national funding for basic research by an amount that is equivalent to the amount of funds to be disbursed through the ERC. It can be expected, however, that national governments are sufficiently convinced of the long-term importance of investing in basic research to resist this temptation. On the other hand it is also true that in the admittedly hypothetical case of perfect substitution of national funding for basic research with ERC funding the gains compared to the current situation and resulting from introducing to the field of basic research the added value of organising the competition for funding between individual research teams at the European level would still be substantial.

Specific Programme 3: Cooperation

Collaborative research

In the modern global economy, it can no longer be expected that single teams or even Member States can provide the necessary scale and scope of resources required to conduct research. For example, as was seen in 2.2., the average research expenditure of an EU-25 country is just over € 7 billion per year, which is around the same amount as the annual R&D spending of the Ford Motor Company.

Evidence suggests, however, that Europe is still some way from having a coherent research area allowing public and private research teams easily to access additional or complementary resources across the EU. Thus the compartmentalization of research teams across Europe needs to be reduced by breaking down the barriers to pan-European cooperation.

As was seen in the previous chapter, FP-induced collaborative research encourages trans-national partnerships, brings together resources, disciplines, scientific excellence, thus achieving a critical mass which could not be attained at national level. Participation of different actors - from university, industry and public research laboratories – and the interaction between these actors is also a key aim of EU collaborative RTD actions.[171] Collaborative research projects enable those research teams wishing to develop their S&T capabilities in specific fields to participate in top transnational teams, benefit from learning and synergies. In this way, the traditional instruments, in conjunction with the new instruments introduced in FP6, have an important structuring effect on the European research system. Moreover, cross-disciplinarity of research is growing, and no Member State can be expert in all fields, especially the emerging ones. Hence researchers must increasingly look beyond their own frontiers if they want to find high-quality expertise in complementary disciplines.

Ending the collaborative research programmes carried out under FP would lead to greater fragmentation and inefficiency of research efforts in Europe. Research teams would carry out fewer projects on a European scale, and would be limited to the resources and knowledge available in their own country. Some important fields of S&T would therefore advance more slowly, while some countries may find that their capabilities in particular research fields are declining due to inadequate interaction with top teams located elsewhere.

Under the option of continuing as under FP6 we might reasonably expect to maintain and continue the benefits produced so far by these actions: e.g. the impact on the quality of research in Europe, which collaborative research programmes are helping to improve, and its increased visibility, in key areas for growth; the dissemination of knowledge and results within the Union; and the ability of researchers to become involved in high-level projects. However, the key weakness of this approach is that it does not take the opportunity to further restructure the EU research system and reduce its inefficiencies.

As shown earlier, the current size of FP intervention for collaborative projects is having a significant effect in restructuring research in the EU, and in pooling and leveraging resources. However, the substantial increase proposed under FP7 will be crucial in distributing these effects more widely, and moving Europe closer to a real "single market" for research. The proposed simplification of rules and procedures of FP7, notably in relation to proposals for research consortia, will also have a significant impact in making the FP easier for applicants and participants, and thus more attractive and useful to the research community. Special attention will also be paid to the horizontal integration of priority scientific areas which cut across themes.

Theme: Health

- ***Health research is one of the main research pillars of all countries in the world*** (45% of the federal funds in the USA). At EU level, it contributes to improving the health of European citizens and to increasing the competitiveness of European health-related industries, while at the same time addressing the challenge of ensuring that sustainable and efficient systems of healthcare are accessible to everyone.

- ***Key sector for greater competitiveness in knowledge, services and technologies***. The recent advances in genomics (including the sequencing of the human genome), proteomics, and their related technologies, have led to a massive increase in data and knowledge with high potential for numerous applications in medicine and biotechnology. The health sector, consisting of the pharmaceutical, medical technology and biotechnological industries, health care workers and health research, is a strategic motor for the EU economy. As of 2002, some 600,000 people were employed in the pharmaceutical industry with a € 20 billion investment in EU-15, amounting to 15% of the whole EU R&D business expenditure. Of the EU-15 population, the health care sector generated 2 million jobs between 1995 and 2001 and employed 10% of the population.[172]

- ***Healthcare biotechnology is one of the leading sectors for innovation***. It is widely expected that biotechnology will continue to innovate and contribute to finding new and more effective diagnostics, drugs, replacement materials and means for tissue regeneration, which will bring effective health benefits. Strong biomedical research is essential for the sustained vitality of this sector, which is expected to lead the new health economy and also strongly benefit the pharmaceutical industry. Entrepreneurship has been intense over the last 10 years in this sector, and today, although these research-based SMEs are greater in number than in US, they are smaller and less mature and require efforts at the EU level to facilitate their development.

- ***European citizens are benefiting from the applications***. Biomedical innovations and alternative methods to animal testing improve the health, quality of life, safety of products and security of European citizens and contribute to maintain solidarity-based health systems, which are typical to Europe and rely on shared values.

- ***Research close to the citizens***. Of all scientific sectors, medicine generates highest level of scientific interest amongst Europeans. This sector has the highest potential for dissemination of scientific knowledge to the general public. Healthcare biotechnology is perceived by Europeans as having far greater benefits and fewer risks or ethical concerns than certain other areas of biotechnology. This research sector also holds the promise of meeting some of the fundamental needs for health threats at the global level and especially those facing the developing world.

Theme: Food, Agriculture and Biotechnology

Life sciences and biotechnology are widely recognised to be, after the information society, the next significant wave of the knowledge-based economy, creating new prospects for our society and economy.[173] The collapse of the ICT bubble in the US in 2000, for instance, resulted in a marked shift to biotechnology at Silicon Valley.[174] As highlighted in recent reports, life sciences provide increasingly vital inputs towards the competitiveness and sustainability of major sectors including pharmaceuticals, food, agriculture, fisheries and aquaculture, energy, textiles and chemicals, and have triggered or accompanied fundamental changes in, for instance, our ways of managing human and animal health, consumer protection, the environment, and production standards for crops and livestock and their derived goods.[175] The transition to a sustainable and competitive economy based largely on renewable resources from agri- and aquaculture – the knowledge-based bio-economy – is as inevitable as it is desirable for Europe. Several arguments support this statement:

- ***The economic potential of food, agriculture and biotechnology is large***. The European bio-economy is growing strongly and presently has a turnover of more than € 1300 billion in the food industry, agriculture and forestry alone. In addition to this, the health and industrial biotechnology market is likely to increase dramatically from the present € 100 billion to reach € 2000 billion by the end of the decade.[176] Research and innovation are crucial to maintaining and strengthening industrial competitiveness and economic growth in all sectors of the bio-economy. Furthermore, the increased use of biological raw materials in many sectors of Europe's industry will be particularly beneficial for the new Member States and Candidate Countries, as their agricultural sectors make up a significant part of their national industries.

- ***Food, agriculture and biotechnology as enabling technologies.*** They are increasingly applied in a wide range of fields for public and private benefit: agricultural and food applications, environmental remediation, process industries (for example, the use of biocatalysts in industrial chemistry), biofuels and biomaterials.

- ***European citizens will benefit from applications.*** Beside biomedical innovations, research will provide safer and healthier food for the well-being of consumers and will ensure that the basic needs of European citizens remain affordable in the context of a growing food demand world-wide.

- ***Research is crucial in the making of sound policies.*** That fundamental role is particularly salient in this area, on important issues such as the Common Agricultural Policy; agriculture and trade matters; food safety regulations; animal health and welfare standards; and the recent Common Fisheries Policy reform aiming to provide sustainable and competitive fisheries and aquaculture.

- ***Life sciences and biotechnology contribute to sustainability.*** Advances in green biotechnology will help to ensure sustainability of agricultural production. Combined with progress in “white” (= industrial) and “blue” (= marine) biotechnology, it will spur the development of new industries transforming renewable biological resources into industrial products (new fuels, chemicals, pharmaceuticals, aromatics, cosmetics, etc.). These technologies have the potential to help decouple industrial growth from environmental degradation and deliver a more resilient economy, which is less susceptible to uncontrollable global events and less dependent on large-scale distribution systems.

Thus, although European scientists have been at the forefront of food, agriculture and biotechnology research up to now, FP7 needs to further intensify and integrate research efforts and allow Europe to maintain its leading position in the field.

Theme: Information and Communication Technologies (ICT)

Information and communication technologies were identified as playing a key role in achieving the Lisbon objectives. This was confirmed at the Spring Council 2004[177] and by the recent Kok report.[178] The role ICT plays in achieving these objectives is fourfold:

- ***The ICT equipment and service sector is an important sector in its own right.*** The sector has grown from 4 percent of EU GDP in the early 1990s to 8 percent today[179], and accounted for 6 per cent of employment in the EU in 2000. Moreover, it is one of the most productive sectors, with average annual productivity growth of 9% over the period 1996-2000.[180]

- ***ICTs are central to boosting productivity, growth and competitiveness.*** 40 per cent of the productivity growth in the EU between 1995 and 2000 was due to ICT[181]. ICT makes this contribution to labour productivity growth through different channels. First, the rapid increase of technological progress in the ICT-producing industries makes a large contribution to growth if these industries expand much more rapidly than other sectors – even if the ICT sector is relatively small.[182] Second, ICT stimulates labour productivity through the use of ICT in the production process.[183] Third, through technology spillovers and network effects, the use of ICT leads to higher TFP (total factor of productivity) growth as well.[184]

- ***ICT improves quality of life.*** The implementation by governments and public administrations of new eServices in the areas of eGovernment, eHealth and eLearning allows more and better service to citizens and increases transparency and openness. ICT is also a powerful tool to promote European diversity and cultural heritage.

- ***ICT drives innovation***. An indigenous research capability is essential in being able to assimilate technology and exploit it to economic and societal advantage. Studies show that the economic performance of countries that are more research-intensive and experience faster technological change is better compared to countries where the technological research effort is lower. This is particularly true for ICT, where innovation moves at an ever faster pace, where the frontiers of research are increasingly broad, and where people and organisations depend more and more on ICT. Clearly, given the fast pace of technology change, investments in ICT Research & Development are a necessary first step in driving innovation and downstream growth across the economy and society as a whole[185].

Despite all these benefits, Europe invests much less on ICT in general and also, with the exception of some northern European countries, Europe reaps less benefit than the US from ICT lead productivity gains. This evidence underlines a need for Europe to invest more in ICT and at the same time, increase its capacity to get the full benefit from its ICT investments.

In addition, FP7 should further exploit the potential offered by ICT to reduce the environmental impacts of economic activities, create greater social inclusion and enable poorer countries to develop more quickly than has been possible in the past.[186] For instance, through providing opportunities for working or trading remotely economic activity is decoupled from a particular geographic location (be it the office, capital cities or structurally favoured regions). Assistive technologies can facilitate access to employment and information among sections of society (physically disabled, the elderly, people in remote or deprived areas) who may otherwise face exclusion from the labour market or socially cohesive networks. Precondition for this is, however, to include criteria of accessibility, pervasive infrastructures, reliable and dependable communications infrastructures.

Theme: Nanosciences, Nanotechnologies, Materials and new Production Technologies

Manufacturing makes up some 75 % of the EU GDP and some 70% of employment in Europe and is therefore most essential to European economy and society. Employment is under pressure due to many factors, ranging from the need for continuous innovation to the strong competition from areas where production is possible at lower cost. The delocalisation of industrial activities appears no longer to be limited only to traditional sectors with a high labour density, but is beginning to be observed in intermediate sectors – which constitute the established strengths of European industry – or even in some high-technology sectors, where there are indications of a delocalisation of some research activities, or in the services sector. Moreover, each lost job in manufacturing will put at risk two jobs in related services.

A strong transformation of industry and of the industrial environment is essential to cope with the various challenges. Such transformation from a resource-intensive industry to a highly competitive and sustainable knowledge-based industry will be achieved;

- in the medium term, by creating new solutions and uses to solve the compatibility problems between the old and the new approaches, filling the gaps that traditionally exist across technical disciplines;
- in the longer term, by creating breakthrough new knowledge for new applications, such as nanosciences and nanotechnologies.

The importance of nanotechnology for European is threefold:

- Nanotechnology is an important sector in its own right. The nanotechnology market is expected to rise from € 2.5 billion in 2003 to several hundreds of billions per year by 2010 and one trillion thereafter. The sector has no winners or losers yet; the EU still has the opportunity to be at the forefront.
- Nanotechnology is an enabling technology. Nanotechnology can permeate virtually all technological sectors. It often brings together different scientific disciplines and is expected to help overcome many technical and non-technical barriers. Revolutionary applications are expected in e.g. the medical pharmaceutical sector and in Information technologies. Nanomaterials will enable a wide range of new technologies and products.
- Nanotechnology contributes to sustainability. Nanotechnology-based developments will open new possibilities for Food, water and environmental research, and for energy production, storage and saving. Nanotechnological products themselves will result from knowledge-intensive but not resource-intensive industries.

However, when comparing Europe, Japan and the USA, it shows that Europe is investing proportionally less in nanotechnology. In 2003, the average level of public investment for the EU-25 was € 2.4 per citizen, compared to € 3.7 for the USA and € 6.2 for Japan. The landscape of European R&D nanotechnology is also becoming increasingly fragmented; co-ordinated research efforts in nanotechnology have to substantially increase.

The main impacts of the aforementioned actions will be to contribute to the transformation of European industry and of the industrial environment, and help to ensure that enterprises' knowledge and manufacturing capacities remain in Europe.

Theme: Energy

As laid down in the new Treaty establishing a Constitution for Europe, EU energy policy aims explicitly at ensuring security of supply, promoting energy efficiency and saving and the development of new and renewable forms of energy. Further objectives include the development of the economic standards of living as well as improved quality of life of European citizens. Energy is fundamental to modern society and to sustainable development. Any energy shortage or insecurity would have serious implications for individuals, communities and business, both immediately and in their planning for the future. Oil price increases and volatility dampen macro-economic growth by raising inflation and unemployment and depressing the value of financial and other assets, producing losses which could be in the order of 0.5% of GDP for each 10% oil price increase – and oil has risen 50% in the last year alone. Facing the depletion of fossil resources, rapid demand growth in large emerging countries and the major issue of climate change, it is clear that our patterns of energy production, transmission, distribution and consumption have to change substantially. Furthermore, it is expected that power consumption in the EU will increase by some 33% by 2030, due to increasing living standards in the EU. To meet the demand of developed and developing countries, the world's energy supply will probably have to at least double over the next 50 years. In the transport sector, the EU has set a strategic target to replace 20% of its road transport fuels by alternative fuels by the year 2020 and has identified three types of fuels that can potentially reach a significant market share: biofuels, natural gas and hydrogen. Within the general context of sustainable development, the main drivers for energy research are therefore security of supply, climate change and economic growth. This major challenge can only be met by a commensurable effort in energy research.

- ***Energy is an important sector in its own right.*** The energy sector is a source of stable and substantial employment. Research on energy technologies will help to de-couple future economic growth from rising energy demand, as well as from the issues of security of supply, environmental impact (especially greenhouse gas emissions), waste management and radio-protection. The EU has set a strategic target to replace 20% of its road transport fuels by alternative fuels by the year 2020 and has identified three types of fuels that can potentially reach a significant market share: biofuels, natural gas and hydrogen.

- ***Energy research is an essential policy instrument.*** Energy research is one of the pillars to implement the EU's policy commitments to improving energy security and reducing dependency on imported energy supplies (Green Paper), to the enhanced competitiveness of European industry (Lisbon agenda), the global need to reduce CO2 emissions (Kyoto), as set out in the Göteborg agenda and sustainable development objectives, to increase energy efficiency and the share of renewable energies in the final energy consumption of the EU-25 (COM(2004)366).

- ***Energy research improves industrial competitiveness****.* The EU power generation industry and its equipment manufacturers currently accounts for about 50% of global world sales estimated to be worth 100b€ per year. This sector is especially vulnerable to fierce competition. Energy research helps to reduce energy costs and generates technical innovations. Both enhance Europe's industrial competitiveness. Europe is at the leading edge in some renewable energies – for example, Europe accounts for almost three quarters of all international wind turbine exports. There is also great potential in equipment for nuclear, clean coal and gas power plants and for the renewable energy sector, in particular for those rapidly developing parts of the world which need to build new energy infrastructures to feed their growth.

- ***Ensuring security and diversity of energy supply.*** According to the Green Paper on Security of Supply, Europe depends to a great extent on imports and if no action is taken, EU dependency on energy imports will increase from 50% to 70% by 2030. No single energy option is capable of meeting this challenge. There is a need for diversity and this has to be reflected in the policy and research agendas, in the new context of competitive and gradually integrating energy markets in Europe and beyond.

- ***Energy research under the EURATOM Treaty makes key contributions to the protection of the environment, and the reduction of greenhouse gas emissions and waste, for present and future nuclear power generation***. One-third of the EU's electricity is currently generated by nuclear power, the only base load carbon-free energy source available in the EU, which is crucial to fulfilling commitments under the Kyoto Protocol. Further research is required to ensure that high levels of safety are maintained, sustainable solutions to outstanding waste management issues are implemented and more efficient and even safer systems can be developed in the future. This will have important benefits for the EU's security of future energy supplies and protection of the environment, at the same time enabling EU industry to retain its world leader status in the increasingly competitive area of nuclear technology and services. Fusion research aims at providing an environmentally friendly and sustainable energy option for the longer term. European research activities will be focussed on the vitally important international ITER project and, in parallel, will prepare the further steps in deploying fusion power. In addition, the EU's leadership in this field strengthens European industry's competitiveness in related technologies (e.g. superconducting magnets). Further significant benefits to industry would follow from the major role it would take if ITER is constructed in Europe.

Theme: Environment (including Climate Change)

To address the different challenges and enhance EU added value, the foundations of environmental research and technological development in the proposed FP7 will be structured along nine issue areas: Pressures on environment and climate; Environment and health; Natural hazards; Conservation and sustainable management of natural and man-made resources; Evolution of marine environments; Environmental Technologies; Technology assessment; Earth observation; Forecasting methods and assessment tools. Expected impacts centre on the following developments:

- ***Environmental research helps understanding and predicting climate change and environmental pressures.*** This will enhance our understanding of interactions between drivers, pressures and impacts related to climate change that will in turn help identifying new policies and strategies.

- ***Environmental research helps filling the knowledge gap on the interaction of environmental stressors with human health.*** Sources, impacts and emerging risk factors identified will allow the design of effective prevention strategies.

- ***Environmental research improves the management of natural resources and services.*** Further understanding of biodiversity as well as of terrestrial and marine ecosystems will support the development of approaches and services for natural resource management.

- ***Environmental research supports the understanding of the marine environment.*** Knowledge in this area will contribute to the design of an all-embracing marine and maritime policy that will help realising the full potential of sea-based activities in an environmentally sustainable manner.

- ***Environmental research develops environmental technologies***. The identification of sustainable and innovative technological solutions that are needed to fully exploit the potential of the natural and man-made environment will contribute to increased growth, competitiveness, the creation of new jobs and improvement of human health conditions.

- ***Environmental research helps understanding natural hazards.*** A better understanding of natural processes will help in designing more efficient warning systems and prevention strategies.

- ***Environmental research facilitates the implementation of the EU sustainable development strategy.*** Enhanced tools will be developed to identify cost-effective and cost-benefit sustainability options, to build scenarios and to carry out impact assessment of policies on the environmental, the economic and social dimensions, including those dealing with land use and urban management**.**

- ***Environmental research supports Earth Observation.*** The collection, treatment and exploitation of environmental, health, economic and social data in a consistent and inter-operable way will improve monitoring of environmental processes for decision-making.

Theme: Transport (including Aeronautics)

The transport sector, encompassing aeronautics and air transport as well as surface transport (rail, road and waterborne) is key to the European economy, having major economic, social and environmental implications.

- ***Transport is an important activity sector in its own right***, which includes vital industries (aeronautics, car, rail, ship) and important shares in the services sector. Altogether they account for some € 1 000 billion, or over 11% of the EU GDP, and employs some 16 million people. Transport by definition is an issue at European level. Thus, also activities to solve problems at European level must be European. E.g. solutions to meet the future demand in air transport the development of the future ATM system can only be defined and driven at the European level.

- ***Transport is a key factor of the modern economy and society.*** It allows the movement of services and goods, helps bringing together people and different cultures and contributes to sustainable development. It supports the functioning of the internal market through its effective integration. The recent transport White Paper[187] stressed its importance, but also highlighted some problems threatening the European competitiveness and the environment. During the 1990s, the European transport network started to suffer from increasing congestion. Some 7 500 km, i.e.10% of the road network, is affected daily with traffic jams. 16 000 km of railways, 20% of the network, are classed as bottlenecks and 16 European airports record delays of more than a quarter of an hour on more than 30% of their flights. Altogether these delays cost the economy € 1.9 billion litres of fuel, which is some 6% of annual consumption. This problem also seriously threatens our economic competitiveness and has serious impacts on environment. Paradoxically, the outermost regions remain poorly connected to the central market. They cost Europe in terms of productivity, lost of opportunities to create new markets and hence in a level of job creation. If nothing is done the cost of congestion will, on its own, account for 1% of the EU's GDP in 2010. Not only congestion, also air and noise pollution affect the quality of life, safety and security are also an important requirement throughout Europe.

The set of problems identified in the White Paper require sustained political action and follow-up under the Lisbon strategy. In support of policy the transport research provides basic methodologies and models to help formulate and assess policies and legislation as well as monitor their implementation.

Theme: Socio-economic Sciences and the Humanities

Because socio-economic sciences and humanities (SESH) are strongly embedded in organized human life, European research in SESH is qualitatively different from national research, which is not the case for natural sciences. Such research is needed for Europe to address the challenges and opportunities associated with the future of organized human life in Europe.

SESH are becoming increasingly important in their own right and European SESH are increasingly important in informing and guiding European choices.

In the absence of strong European efforts in SESH, European institutions would jeopardize their capacity for strategic analysis and their decision-making processes would lack a scientific understanding of European societal and cultural realities. Europe's capacity to understand its own diversity would decrease and so will its ability to harness diversity for the benefit all Europeans, and to develop a well functioning democracy and continue to be the lighthouse of civilization that it deserves to be.

In FP7, collaborative research will play a central role addressing important questions that underpin major policy choices. Actions will be structured around seven issue areas (growth, employment and competitiveness in a knowledge society; combining economic, social and sustainability objectives; trends in society; Europe in the world; the citizen in the EU; socio-economic and scientific indicators; foresight activities). In those areas, there will substantial policy impacts, which will bring about better policy discussions and decisions from a European perspective.

Three other major elements will increase the impact of research in SESH on policy, the economy and society: a better integration of SESH in the thematic research areas of a more technical/natural science character; a further use of the ERA-NET scheme in SESH; the development of "platforms" focusing on societal issues (possibly driven by industry), which will improve the strategic interaction between producers and users of SESH research.

FP7 will thus contribute to solid evidence-based European policies which will drastically improve competitiveness, employment and quality of life; provide for evidence-based management choices which will improve efficiency and productivity of public services; and promote the development of a reflexive European knowledge based society which makes conscious choices and decisions about its future and the future of the world.

Theme: Security and Space

Security

The world and Europe are being affected by profound changes, which equally impact the Security scene. Political, societal and technological developments have created a security environment where risks and vulnerabilities are more diverse and less visible. New threats have emerged which ignore state borders and target European interest both within and outside the EU territory. Large-scale aggression against any Member State is not improbable and threats include terrorism, proliferation of weapons of mass destruction, regional conflicts, state failure and crime. At the same time, globalisation is strengthening Europe's link with the rest of the world and fosters its integration into an emerging global society. The need to address the new security situation, and the role of a strong industrial and technology base has been stressed by the Heads of state on various occasions: the Cologne European Council emphasised the need for a competitive and dynamic industrial and defence base; the Lisbon Council stressed the need for a competitive knowledge-based security and the Barcelona Council called for a boost of the overall research, development and innovation efforts in the Union.[188]

In today's technology-driven and knowledge-based world, excellence in research is a prerequisite for the ability to tackle the new security challenges.[189] Technology itself cannot guarantee security, but security without the support of technology is impossible.[190] The cost of "non-action" could be unacceptably high – both politically and for the European citizens.[191]

• ***A coherent security research programme can add significant value to the optimal use of a highly competent industry.***[192] Security research can strengthen the development of a competitive industrial base in security and defence. Europe should aim to build an indigenous competitive capability for critical technologies.

• ***State-of-the-art technologies are necessary to contribute to building an area of security, freedom and justice***. The enlargement process has resulted in a sizeable territorial increase and the EU25 will have borders with less stable regions. It is European interest that countries on our borders are well-governed. Security research contributes to a consistently high level of security in a new, more diverse territory.[193] The protection of the European citizen and the fulfilment of crisis management and humanitarian actions within a credible CFSP and ESDP depend to a large extent on the availability of leading edge technologies.

• ***Security is a precondition for development.*** In many cases, economic failure is linked to political problems and violent conflicts. Conflict not only destroys infrastructure (including social infrastructure); it also encourages criminality, discourages investments and makes normal economic activity impossible. A number of countries and regions are caught in a cycle of conflict, insecurity and poverty. The competition for natural resources is likely to create further turbulence and migratory movement.

In comparison to other regions in the world, there is a recognised under investment in RTD in this area. Based on a number of parameters and scenarios, including but not limited to US investments in this area, a budget of around € 4 000 million for the period 2007-2013 appears desirable.[194]

Space

Over the past few decades, European efforts in the field of space have made it possible to create a solid industrial base and obtain recognised capability in the field of launchers, science and technology, and applications (in particular telecommunication satellites). Space represents a tool with unique characteristics at the service of numerous objectives and policies (e.g. transport and mobility; information society; environmental protection; land use planning) and more generally of the Lisbon strategy aiming at "making the Union the most advanced knowledge-based society in the world". Research activities are fundamental for maintaining and improving the competitiveness of Europe in this highly technological and rapidly evolving field. The importance of space for the future of Europe is threefold:

• ***Space contributes to economic growth and employment.*** Today, the European space sector directly employs 30 000 highly qualified people. World-wide the space applications-related market is estimated at € 350 billion by 2010 and each Euro invested in space applications generates a turnover of € 7-8 due to the development of added value services.[195] For example, studies carried out when the GALILEO programme was being devised, indicated that macroeconomic benefits, which can be achieved over a 20 year period, amount to about €18 billion, combined with the creation of 145 000 related jobs. Furthermore, its market outlook is promising: demand for satellite navigation services and derived products around the world is growing at a rapid 25% a year and could reach € 275 billion by 2020, in the process creating 100 000 skilled jobs.

• ***Space improves quality of life.*** European citizens benefit to a large extent from space solutions. New communication opportunities, radio navigation possibilities, disaster prevention tools, and improved meteorological forecasts, for instance, are just a few examples of space applications that have radically changed our daily life. Further research in the context of the Global Monitoring for Environment and Security (GMES)[196] and in satellite telecommunications can help enhancing European capabilities to face major natural disasters and improve the citizen awareness of environmental changes. Improved communication will also contribute to closing the digital divide with the new Member States and beyond in complement with global solutions.[197] The Union is the largest provider of development in the world. Space technologies can strengthen it development efforts, and help other countries to develop access to information, raise skills levels and better manage their resources.

- ***Space contributes to sustainable development.*** Earth observations from space support sound environmental management and protection by providing basic homogeneous observations with coverage on climate and weather, oceans, fisheries, land and vegetation.[198] The data collected by space systems are complementary to the necessary ground, air and sea-borne systems and contribute to Europe's capacity for Global Monitoring for Environment and Security (GMES), which enables the efficient management of natural resources.

The actual and potential benefits of space technologies cannot be secured under present institutional and budgetary arrangements. The current situation and the prospects for the future of the European space sector are worrying. The US invests five times as much in space than the EU-15. The EU-15 has a public investment of about 0,06% of its GDP in space activities against an investment of 0.3% of GDP in the US. This evidence underlines a need for Europe to invest more in space and at the same time, increase its capacity to get the full benefit from its space investments. This should be accompanied by the implementation of a better governance scheme where roles and responsibilities of different stakeholders (EU, ESA, national agencies, private sector) have to be assigned.

Doing nothing will leave Europe vulnerable to two real dangers. First, if its growth does not keep pace with the global evolution in the space sector its capacities as a key space player will decline and its ability to develop and sustain new technologies and applications could be jeopardized. Second, weak commercial markets and a lack of public investment in new programmes will cause a decline of its leading space companies. Today, the European space sector directly employs 30 000 highly qualified people, and nearly 30% of them are due to retire in the next 10 years. Increasing the flow of young scientists and engineers into the space sector space will help to rejuvenate and strengthen the space sector.

Joint Technology Initiatives

European industries urgently need to maintain and further improve their competitiveness. This has been confirmed by the Kok and Sapir reports. Many are mainly medium-tech and, while highly productive, are also characterised by rather expensive and inflexible labour. This puts them under increasing competitive pressure from major high-tech competitors, notably the US and Japan and, increasingly, from "*lower-cost, high-tech*" countries such as China, India, Brazil and South Korea.

European industries urgently need to become more knowledge-intensive and to innovate, with a view to ongoing introduction of new products and processes and raising of productivity. Efforts in that direction necessarily need to start with the research base. The implementation of large-scale, strategic research agendas will help European industries to improve their competitiveness. The implementation of such agendas assumes the European-wide mobilisation of most if not all actors within a particular industry as well as the sustained allocation of large-scale funding to R&D.

The proposed option consists of allocating, in collaboration with the private sector under a public-private partnership, such large-scale funding to a limited number of Joint Technology Initiatives (JTIs).[199] A JTI is an implementation mechanism supported by a broader Technology Platform (TP). In order to create a JTI, a TP needs to have developed an ambitious, large-scale, strategic research agenda that is sufficiently mature, and the main industries concerned need to be committed, including financially, to its implementation. The research to be implemented should be state-of-the-art, and have multiple users, have wide economic/social/environmental benefits, and European intervention should be required for its implementation.

The implementation of JTIs will contribute to the achievement of the Lisbon competitiveness objective and the Barcelona 3 percent and two-thirds objectives. The contribution to the former will be made through the formulation for areas critical for European competitiveness of ambitious, long-term and strategic research and wider policy agendas, and by committing a critical mass of financial, organisational and human resources to their realisation under public-private partnerships. This will subsequently lead to new products and processes, European leadership in these areas, the tying down of those industries to Europe, and international trade competitiveness. The contribution to the achievement of the Barcelona objectives lies in the large-scale mobilization of very substantial R&D investment, with an indicative one-third to be financed by the public sector and two-thirds to be financed by the private sector.

Since the aim is to accomplish a large-scale mobilisation of all actors in a particular technological area, industrial participants in new Member States and Candidate Countries will be provided with an opportunity to improve their capabilities.

A number of risks have to be noted. It can be anticipated that the mobilisation of all the relevant actors and the setting up of a JTI could be a lengthy process. It is also necessary to ensure before embarking on this approach that the industries concerned are sufficiently committed to the implementation of the strategic research agenda in the long-term and not merely seeking to obtain FP7 funding in the shorter-term. Finally, given the leading edge nature of the research to be undertaken, there will be the associated technological risks.

Coordination of national research programmes

The importance of the coordination of the national programmes is obvious when one considers the amount of funding concerned. The Framework Programme accounts for only 6% of the total public R&D expenditure in the EU, while, for example, the annual budget of DFG in Germany is over € 1 000 million and that of CNRS in France is over € 2 000 million. However, publicly financed research and innovation programmes remain largely uncoordinated and are still defined separately in each Member State in many regions (see I. 2.2.).

The effect of discontinuing actions to promote coordination of national programmes would be to return to the complete fragmentation of the pre-ERA period, with 25 Member States and numerous regions defining their research priorities independently from each other and from the EU. The result would be the waste of already scarce resources and a lost opportunity to restructure the European research fabric so as to enhance EU competitiveness.

Continuing with the current scale and scope of ERA-NET and Article 169 activities would have an important impact, but would represent a missed opportunity for the deepening of coordination activities. The expected outcomes under FP6 are significant, and these could be expected to continue: coordinated research strategies, improved evaluation schemes, better trained programme managers and exchange of best practice, less duplication and better use of research funds (i.e. more innovation), reduction of administrative and legal hurdles to coordination, and leverage effects (an EU contribution of up to € 3 million per project mobilises potentials of research funds from € 20 million to several € hundred million per ERA-NET). However, demand for such actions is currently high (for ERA-NET there are roughly twice as many proposals than can be funded), and more and more Member States express their interest in joining projects in progress. At the same time, both ERA-NET and Article 169 need to be adapted to take into account lessons learnt from FP6.

The approach proposed for FP7 is to build upon the success of these activities, and to respond to strong demand, by increasing the budget and extending their scope/areas covered. A number of suggestions have been made to increase the impact of the scheme, notably by foreseeing the possibility that the EU contribute also to the costs of the research, since the support of only the coordination activities is a limiting factor for further integration, and to introduce an intermediate scheme between ERA-NET the joint programmes under Article 169. An upgraded, more powerful scheme, “ERA-NET PLUS”, will therefore be proposed. The new “ERA-NET PLUS”, will therefore contribute more strongly to the restructuring of the European research fabric in a coordinated and organised way and thus to the development of the ERA. As for Article 169, the number of joint programmes would be increased and other fields of research would be included, thus strengthening the impact on the ERA.

International cooperation

International research cooperation helps to stimulate socio-economic development and global competitiveness, and contributes to Europe’s many key international commitments (e.g. Kyoto, Convention on Biological Diversity, Biosafety Protocol, the Plan of Implementation adopted at the World Summit on Sustainable Development). Its scientific achievements have had a significant global impact – notably in developing countries, the Mediterranean, the Western Balkans and newly independent countries of the former Soviet Union – and cover key areas such as agriculture, human health, food processing, post-harvest conservation, water treatment, erosion and environmental protection. For Europe, such cooperation provides access to knowledge and institutions in other parts of the world, helps it deliver its policies (e.g. environment, food safety, health etc.), and creates a favourable environment for other forms of international alliances.

To adopt a ‘do nothing’ approach in this area would mean that Europe reneges on its commitments in international fora and goes entirely against the trend whereby other industrialised countries/regions are seeking to expand their international S&T cooperation.

Continuing ‘business as usual’ would also be totally out of step with accelerating globalisation and would accentuate fragmentation and insufficient impact of current international S&T cooperation. The absence of a clear international strategy formulation that governs use of existing instruments in FP6, combined with lower than expected attractiveness of new routes to international cooperation (opening of thematic priorities, Marie Curie), has reduced the overall international performance/impact despite initial progress in relation to dialogue fora and S&T agreements.

The top priority in FP7 in the domain of international cooperation is the strengthening of bi-regional/ bilateral dialogues to guide and set the framework for S&T cooperation, and the joint identification of mutual interest research. Implementation could rely to some extent on existing instruments provided significantly increased resources are allocated commensurate with the new challenges identified above. Moreover, a new instrument is required to lend additional credibility and impact to S&T agreements through funding of joint activities and participation of European researchers and their institutions in the research systems of third countries.

Specific Programme 4: Capacities

Research infrastructures

Research Infrastructures are needed for the scientific and technological development of top-class research activities, for both basic and applied research. Construction and operating costs are high. No Member State on its own has the resources required to create the new large scale infrastructures that are required to compete with the US and Japan in particular.[200] Sharing access to such facilities helps to ensure that the benefits to investment are maximised. The existence of recognised world-level infrastructures allows Europe to remain strongly present in the international 'research market'.

Discontinuing the research infrastructures action at EU level would serve to increase the inefficiency and fragmentation of the European research landscape, and would mean less coordination of efforts, less possibility to share costs and access, potential duplication and, in some cases, loss of research capability. In the medium to long term, this approach would produce a decline in EU capabilities to develop pan-European strategic projects, the reduced significance of the research fields involved, damage to the European Research Area, and in the end, to the European economy.

Extending the FP6 approach would consolidate the gains made under that programme: for example, access to the best RI and improved knowledge (e.g. in fields such as nanotechnology), reduction of investment costs through avoiding overlaps, reinforcement of RIs in the field of social sciences and humanities and in environmental sciences, mobility of RI users and researchers (about 20 000 for FP6 related activities alone), world leadership on virtual eInfrastructures, and contribution to the development of European research standards. However, this option would not meet the high and unsatisfied demand for such, and would fail to address the important improvements still needed. Leaving funding at its current level, and limiting intervention to FP6 actions, would lead to a continued oversubscription, and thus frustration and increasing criticism from the scientific community. EU scientists affected would move towards regions that promote better development of research capacities, such as the USA.

The time is ripe for better co-ordination in this field and for the development of a 'true' ambitious EU policy on Research Infrastructures. FP7 can contribute substantially through:

- the improvement and reinforcement of the existing schemes to optimise the use of existing RI and improve their performance (mainly through a "bottom-up" approach);

- a component of the RI programme linking to the thematic priorities and their priority topics, with a range of instruments appropriate to the needs of each type of infrastructure.

- support for the development of RI of European interest (support for the design, engineering, construction, operation, major upgrade), based on a ("top-down") strategic vision for research infrastructures – including a roadmap for EU-RIs; more targeted support for specific research infrastructure projects; and increased use of financial engineering mechanisms to support such RIs.

The new policy initiatives, more targeted towards priorities in the medium to long term, will allow better efficiency of public funds and stimulation of increased synergies between public and private funds. They will also cater for the seamless access to all kinds of resources spread throughout Europe and the world (from computers to large instruments, from databases to communication networks), thus contributing to implement the concept of "Virtual Research Organisation" so important to dramatically improve the way in which science is done.

The setting up of clearer priorities in the field of infrastructure will allow the research community to develop more ambitious research activities, promote more targeted sharing of knowledge and cross-fertilization, and help infrastructure owners/operators to better co-ordinate their efforts and use their resources more effectively. In parallel, through better awareness, participation of industry and new MS as well as the smaller MS would tend to increase.

Research for the benefit of SMEs

Growing numbers of SMEs are confronted with increased competition resulting from the EU internal market, forcing them to internationalise in search of new markets, to innovate constantly and to accommodate advances in technology. European support is necessary to mobilise the SME community to contribute to the achievement of the Lisbon and Barcelona objectives. Through supporting trans-national cooperation, RTD framework programmes enable SMEs to find partners beyond their local communities and support regional development, employment and social cohesion.

Discontinuing the EU funding for SMEs' research and innovation activities would deprive European SMEs of important resources and opportunities to remain competitive in a global economy. Although the added value of collaborative research for SMEs is in principle the same as for other types of participants, many research performing SMEs, unlike large companies which are used to cooperate internationally, have specific difficulties in extending their technology collaboration beyond national borders and national support programmes are often not encouraging or helping them to do so. EU programmes have therefore a specific added value for SMEs.

A continuation of FP6 would also be inadequate; further mobilisation of the SME sector is crucial for strengthening the competitiveness of the European economy and improving its capacity for innovation. The consultation of stakeholders has shown support for a stepping up of SMEs' actions in EU research policy, a simplification of the administrative procedures, and an overall increase in the contribution of the FP to support research for SMEs.

FP7 will address these issues directly. It will further encourage and facilitate the effective participation of (mainly) research performing SMEs across the Framework Programme through the systematic implementation of a set of measures which will tackle the various impediments to their participation without introducing discriminative criteria in their favour. A systematic effort will also be made to indicate relevance and added value to SMEs in all areas of collaborative research, so as to encourage and facilitate their involvement. Helping SMEs with research potential to form the appropriate transnational partnerships will have an important impact on improving the competitiveness of the European economy, by offering a platform for collaboration between research teams and businesses at the international level, strengthening the potential for innovation and supporting the diffusion of research results. Measures to promote the participation of SMEs in FP7 by supporting awareness and assistance actions undertaken by intermediaries and networks of business service providers will be funded under the new Competitiveness and Innovation Programme.

FP7 will also increase support of SMEs and SMEs associations which need to outsource research, thereby improving their capacity to innovate through a better use of European research competencies and diffusion of technologies. This concerns mainly SMEs in low to medium tech sectors but also high tech SMEs which need to outsource part of their research. Such firms increasingly need trans-national research co-operation to solve their scientific and technological problems and to raise their competitiveness. Increased support will respond to the urgent needs of this large and growing, business community and contribute to the development of a high quality research service market at the European level. Improvements in the support schemes (e.g. inclusion of training and demonstration activities, flexibility regarding IPR aspects) should also enhance their effectiveness through a wider diffusion and take-up of the results.

Regions of knowledge

European regions, defined as sub-national entities, are increasingly recognised as important players in the continent's research landscape. Policy makers, practitioners and academics are most likely to tackle a number of critical issues linked to investment in R&D and capitalisation of knowledge, at regional level. The regional setting, properly engineered has the capacity to become a real "forage and breeding ground" for the knowledge economy, if coupled with the appropriate intermediary mechanisms and organisations. The growing significance of research policy and activities at regional level often manifests as cluster policy (shaping research priorities and research funding to fit regional needs, stimulating networks, knowledge transfer etc.), new competences for regional authorities and regional authorities creating new structures (e.g. Public-Private Partnerships) or mandating universities and other research "performers" to undertake this policy.

The 'do-nothing' option will mean that there will hardly exist, if any at all, possibilities for regional actors to exchange good practices, to engage in mutual learning, to join forces with similar regions in other countries and to optimise all possible funding sources for R&D. The situation where policies, activities, and actors lack a way to add a European dimension to their activities will continue and duplication and overlap will consume the already scarce resources at regional level.

The option 'business-as-usual' means continuing with the successful 'Regions of Knowledge' activity that started as a Pilot Action in 2003 and continued as a policy initiative ('Regions of Knowledge-2') under FP6. This scheme shows very encouraging results in presenting regions with a tool to focus on the Barcelona objective at regional level.[201] However, the current scope of the pilot action is limited and does not allow for the mobilisation of critical mass. The scheme as it is now is not sufficiently bold to reinforce endogenous R&D capacity strategically with a view both to produce new knowledge and to increase capacity to absorb knowledge. The positive impacts emerging from linking the science with the industry base at regional level more effectively will fail to materialise.

The actions proposed under FP7 intend to build on the preliminary successes of FP6 and expand the workings to more regions addressing all aspects of policy development and policy decision in the area of R&D. This means enabling regions to strengthen local capacity for investing in R&D, to optimise all possible funding sources for R&D (including Structural Funds), and to maximise their potential for a successful involvement in FP projects. The impact on European competitiveness will be major since attention to a more regions' driven R&D policy can lead either to generation of new high value-added activities or to the successful transformation of declining industrial clusters. At a moment when industrial delocalisation hits several European regions, it would be important to set the basis for new pathways for capitalising knowledge and create growth and employment in a more balanced setting throughout the European territory.

Research potential

In order to achieve the Lisbon Agenda, Europe needs to realise the full research potential of the enlarged Union. This will require not only the necessary financial means but also the mobilisation of all available resources, including those that have not yet reached their full potential, and in particular in the convergence regions of the EU (including outermost regions).

Under a specific new FP7 scheme, collaboration of research groups in the cohesion regions with other EU research centres will be expanded and strengthened. This is expected to increase the international recognition and leadership potential of these regions, as well as the quality of their scientists. This should in turn lay the foundations for their long-term sustainable development, and increase their visibility, while facilitating their participation as equal partners in the EU and international research arenas. The exchange and mobility of staff, along with support in terms of equipment, should help to strengthen the EU knowledge base. Overall, these actions should lead to the fuller and more efficient use of the S&T potential within the EU.

Science in society

Research policy cannot be disconnected from the wider societal context, and so a major increase in European public RTD spending should go hand-in-hand with a step change in the relationship between science and society. There are many challenges to be faced. Research should better engage with European citizens through a transparent culture of explanation, consultation and dialogue. The economic return on RTD investment cannot be realised without public trust, and therefore without appropriate scientific advice and risk governance systems. For new frontier technologies (including 'converging technologies') a debate on the social, legal and ethical implications must be launched at an early stage. European research inevitably runs up against diverse public attitudes and regulatory settings. We need to understand and clarify the positions held by different actors across Europe, recognising that stances vary from state to state. And at a time when we need more scientists to exploit a rising public and private research spending consistent with the Barcelona "3% target", scientific literacy is falling, too few young people choose to take up scientific careers, qualified women scientists continue to leave science in disproportionate numbers compared to their male colleagues, and European research institutions do not yet attract enough researchers so that some of our best brains continue to work outside Europe.

Against this background, it is clear that such actions need to be continued and reinforced. An EU research programme in which Science and Society is strong and visible will help address societal concerns and aspirations in relation, for example, to the biotechnology revolution, food safety issues, health threats, or environmental issues.

The aim is now to build on the impetus given by the "Science and Society" theme implemented – for the first time in Community research – under FP6. It will be further reinforced by bringing into play all the endeavours pertaining to science in its relations with society – and in support of the development of policies considered in this context. Thus this covers important and interrelated issues such as: scientific advice and expertise, science communication and popularisation, scientific publications, science education, ethics, philosophy and sociology of science and technology, national and regional innovation systems, foresight studies, technology assessment, risk assessment, impact assessment, S&T policies (indicators, analyses). Such a consolidation will allow for more synergies and more coherence. This will also enable these avenues of research to play their full role of strategic support to policy-making.

A coherent action in FP7 will contribute to reducing the gap between technology producers and technology users, and to ensuring that societal dimensions, including the gender dimension, are integrated in research content where appropriate. Reinforced efforts under FP7 should also encourage more educated young people to envisage careers in Europe in science, technology and engineering. It should help to promote science among young people at school, and to stimulate European research universities to perform well enough to attract and keep them, while also improving women's access to successful scientific careers, including those in industry.

Specifically, five objectives are envisaged which will help to: ensure confidence in European research and applications; create an environment which triggers an enthusiasm for science in young people, and which provides fair and rewarding career opportunities for women and men; strengthen the European science system; promote responsibility in science through global partnerships; and step up the level of communication between the scientific world and the wider audience of policy-makers, user communities, the media and the general public.

In addition, the capacities programme would also support the coherent development of policies. In order to achieve the Lisbon agenda Europe needs to increase and improve investment in R&D. This notably depends on increasing the effectiveness of Europe's research system, improving framework conditions and increasing the leverage effect of public spending on private investment. This requires more effective and coherent national and EU research policies and better articulation with other policies. The approach proposed for FP7 will allow national and regional policy makers to fully benefit from the activities on monitoring and analysis of research related indicators, public policies and industrial strategies, it will provide Member States additional resources to undertake policy coordination in a wider range of areas they consider it necessary and will widen the scope of areas where Community initiatives could be developed to reinforce national policies.

Section 3: What are the impacts of FP7 on the achievement of the Lisbon, Göteborg, Barcelona and other Community objectives?

After presenting (1) the key considerations driving EU RTD policy, (2) the three basic policy options, and (3) the expected impacts of the Specific Programmes FP7 is composed of, the purpose of this section is to discuss the expected aggregate economic, social and environmental impacts of the policy options. So in this section, attention is focused on the impact of FP7 on the achievement of the Lisbon, Barcelona and other Community objectives. Whereas FP6 was conceived as the main instrument to realize the European Research Area (ERA), FP7's main objective will be to help achieve the Lisbon agenda. At the March 2000 Lisbon European Council, the European Union set itself a new strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion. Further, at the June 2001 Göteborg European Council, a strategy for sustainable development was agreed upon and an environmental dimension added to the Lisbon process for employment, economic reform and social cohesion.

Finally, at the March 2002 Barcelona European Council, it was agreed that overall spending on R&D and innovation in the Union should be increased with the aim of approaching 3 percent of GDP by 2010. Two-thirds of this new investment should come from the private sector. FP7 will make a significant contribution to all of these objectives. We present the main projected impacts of FP7 along three dimensions: economic, social and environmental.

It is important to highlight that in this section we go further than just analysing the expected aggregate impact of the three basic policy options. In particular in the parts on economic impacts, we also develop a number of sub-options, sub-scenarios as it were, that allow for a better insight into how best to optimize the policy design.

The NEMESIS-bis Model

Below, under 'growth', 'employment', 'competitiveness' and 'R&D intensity' are presented the results from an in-depth analysis carried out through an adapted version of the NEMESIS econometric model. The original NEMESIS model was built to estimate the impact on the European economy of reaching the Barcelona 2002 objectives (R&D intensity of 3 percent of GDP, two-thirds financed by the private sector). **Appendix 1** provides a more detailed description of the original NEMESIS model. The adapted version allows for estimating the impact on the European economy of the FP. It has to be noted that with all econometric modelling a certain degree of uncertainty is associated. The NEMESIS model was developed under FP5.[202]

As described in **Appendix 1**, **9 different sub-options** have been carefully assessed in comparison with **2 reference scenarios.** For a detailed overview of the assumptions underlying the 2 reference scenarios and each of the 9 different sub-options, please see Appendix 1. The differences between the different sub-options relate to, for instance, the rate of growth of FP funding after doubling funding under FP7 (e.g. moderate growth vs. continued rapid growth), or the criteria on the basis of which FP funding will be allocated to countries and sectors (e.g. share in EU R&D expenditure vs. scientific and innovative performance); the crowding-in/out effect of European research funding; and the multiplier effect of European funded research. The number of scenarios that could be imagined with regard to the size of the FP is without limit: increasing FP funding under FP7 by 25 percent, 50 percent, 75 percent, etc. Here, however, we have focused on the three aforementioned basic policy options (do-nothing, business-as-usual, doubling the size of the FP) and on providing in this way a range of minimum and maximum impacts. The impact of each scenario is estimated for each year in the period 2010-2030. Results are presented as deviations in a positive or a negative direction from business-as-usual or reference scenarios.

The FP achieves large impacts

Compared to its modest share of European public R&D funding, the FP can be assumed to achieve large impacts, especially in the long-term, and no matter what economic variable is considered. That is due to two contributing factors unique to the FP. The first one is that it can be assumed that the so-called crowding-in effect of FP funding is higher than that of national research funding. So FP funding generates more additional business R&D expenditure than national research funding. The reason is the higher relative attractiveness to companies all over Europe of participating in high-quality cross-border research projects such as those funded under the FP. The second explanatory factor is that it can be assumed that FP funding has a higher impact on economic variables than nationally funded research. In other words, it is characterised by a higher so-called economic multiplier. That is due to the internationally collaborative nature of FP funded research projects. Such projects almost by definition achieve higher pan-European research result dissemination rates than nationally funded research projects. In addition, the EC pursues pro-active dissemination strategies within the context of the FP.

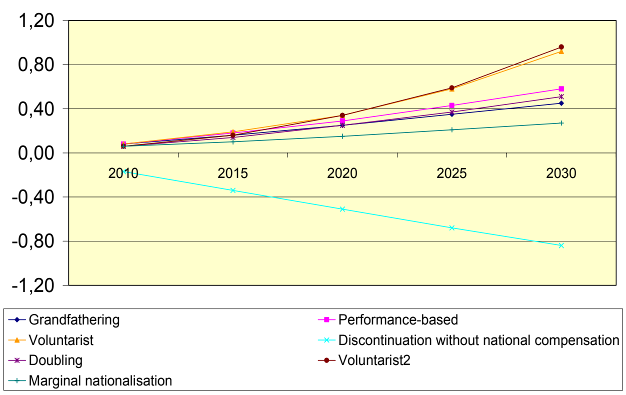
While instrumental in the short-term, the FP achieves its largest impacts in the mid- to long-term

It takes several years between the beginning and the end of the innovation cycle. Carrying out research, generating useful research results, transforming them into product and process innovations, and valorising them through higher turnover etc. takes time. That means that the maximum incremental effect of doubling the FP will take time to show. Clear positive effects will start to show from the years 2010-2015 onwards, however.

The FP boosts Europe's economic growth rate

Through its impact on product and process innovation and economic valorisation, FP funded research boosts Europe's economic growth. All scenarios assuming that FP7 will be twice the size of FP6 generate substantial extra economic growth over and above the business-as-usual scenario of moderate FP growth. The best results are achieved when FP funding continues to grow rapidly after FP7: up to 0.96 percent extra GDP by the year 2030. In other words, assuming a GDP of 100 under the business-as-usual scenario for the year 2030, and given that the extra GDP generated by doubling FP funding would amount to 0.96 percent of GDP by that same year, then total GDP would reach 100.96 in the year 2030. Attractive results are also achieved when post-FP7 growth is more moderate. In that case, however, a performance-based funding allocation mechanism appears to work best.

Figure 12: Impact of the FP on GDP, 2010-2030



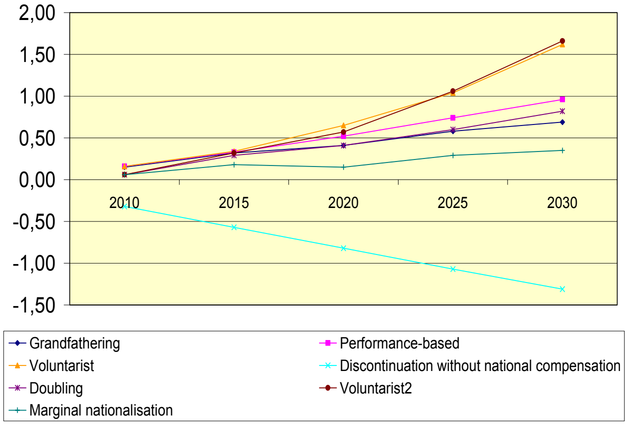
Source: DG Research Data: NEMESIS-bis model

A hypothetical discontinuation of the FP would clearly have a negative effect on Europe's economic growth performance. Compared to the business-as-usual scenario of moderate FP growth, Europe's

GDP would be reduced by 0.84 percent by the year 2030.

Correcting GDP for quality – i.e. taking account of the fact that as a result of technical progress the quality and capabilities of products increase significantly - only serves to highlight the differences between the different scenarios. An initial doubling of the FP followed by rapid FP growth thereafter now increases Europe's GDP by up to 1.66 percent by the year 2030 over and above the business-as-usual scenario. On the other hand, discontinuing the FP reduces European GDP by no less than 1.31 percent by the year 2030 compared to the baseline scenario of moderate FP growth.

Figure 13: Impact of the FP on GDP corrected for quality, 2010-2030

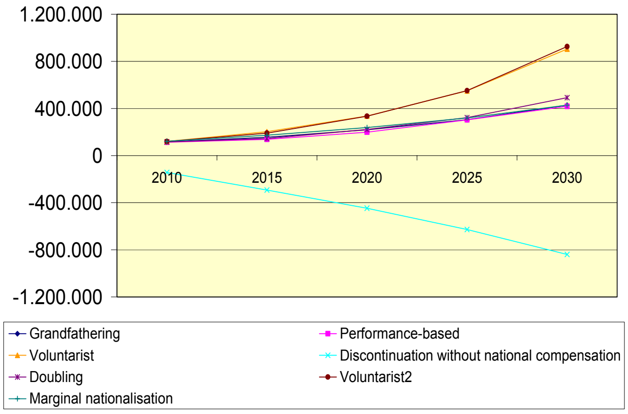


Source: DG Research Data: NEMESIS-bis model

The FP creates extra jobs for European citizens

The direct and indirect employment creation effects of the FP are substantial. If FP7 increases to twice the size of FP6, then at least 418,000 extra (over and above the business-as-usual scenario of moderate FP growth) jobs will be created by the year 2030, regardless of the post-FP7 funding growth path. Should the FP continue to grow rapidly after FP7 too, however, then the number of extra jobs created could reach 925 000.

Figure 14: Impact of the FP on total employment, 2010-2030

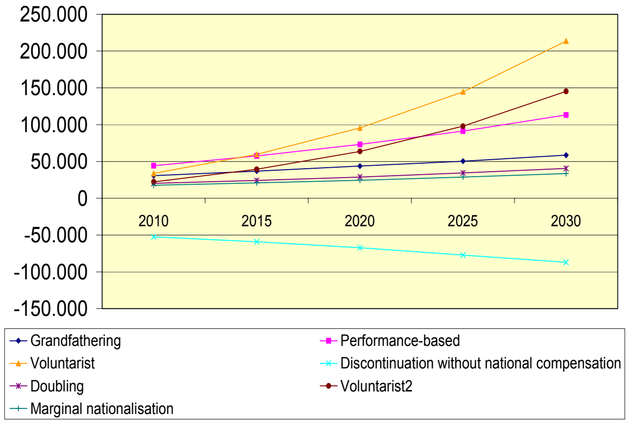


Source: DG Research Data: NEMESIS-bis model

On the other hand, a supposed complete discontinuation of the FP without any form of compensation by the EU member states would result in 840 000 jobs lost compared to the baseline scenario.

A substantial part of the FP impact on employment is direct, i.e. research-related. At least 40 000 and up to 214 000 research-related jobs are created under the scenarios that assume a doubling of funding under FP7. An imagined entire discontinuation of the FP would lead to a loss of 87 000 research-related jobs in Europe by the year 2030.

Figure 15: Impact of the FP on research employment, 2010-2030



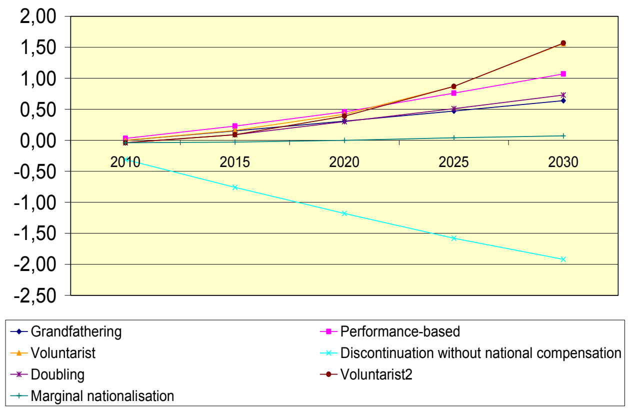
Source: DG Research Data: NEMESIS-bis model

The FP lifts Europe's competitiveness

The FP will improve Europe's competitive position in international markets. This is first of all reflected in the fact that, assuming a doubling of funding under FP7 and moderate growth thereafter, exports will increase by an extra 0.64 percent by the year 2030 over and above the business-as-usual scenario of moderate FP growth throughout. Assuming moreover a rapid growth in FP funding after FP7, this percentage could increase to 1.57 percent.

On the other hand, a hypothetical complete discontinuation of the FP without national compensation would lead to a loss of 1.92 percent of export growth compared to the baseline scenario.

Figure 16: Impact of the FP on extra-European exports, 2010-2030

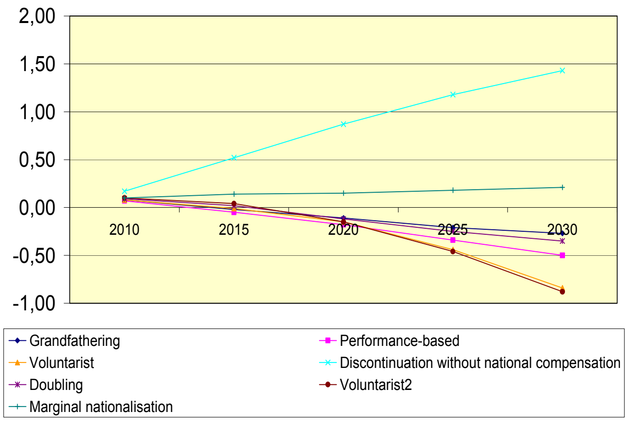


Source: DG Research Data: NEMESIS-bis model
Note: Exchange rates not taken account of in calculation of effect on exports

The improvement in Europe's international competitive position would also be reflected in a reduction of imports. All scenarios assuming a doubling of funding under FP7 reduce imports by at least 0.27 percent. In the case of continued rapid growth of FP funding after FP7, this reduction could grow to 0.88 percent.

An assumed full discontinuation of the FP would have the completely reverse effect. Imports would increase by no less than 1.43 percent compared to the baseline scenario of moderate FP growth.

Figure 17: Impact of the FP on extra-European imports, 2010-2030



Source: DG Research Data: NEMESIS-bis model
Note: Exchange rates not taken account of in calculation of effect on imports

The FP raises Europe's R&D intensity

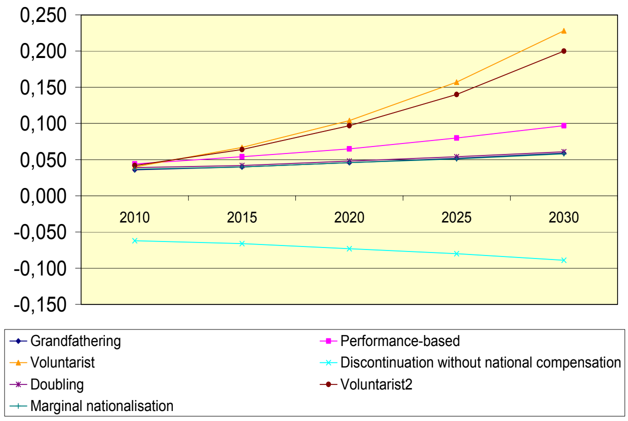
Doubling the size of the FP under FP7 would raise Europe's R&D intensity by at least .06 percent. That is remarkable given the relatively small share of FP funding in total European public R&D financing. In the case of consistent rapid growth of FP funding also after FP7, Europe's R&D intensity could grow by up to 0.2 percent (note that, assuming a baseline R&D intensity of 2%, this would represent a 10% increase). A presumed discontinuation of the FP, on the other hand, would shave off .09 percent of Europe's R&D intensity.

FP funding is at least as effective as national funding

FP funding is at least as effective as national research funding. This is clear from comparing the results for the 'doubling' and 'marginal nationalisation' scenarios. The former assumes that FP funding is doubled under FP7, while the latter assumes that, rather than FP funding doubling under FP7, national research funding increases by an equivalent amount. In other words, a comparison of these two scenarios serves to illustrate the relative efficiency of FP vs. national disbursement of research funding.

It is clear that the disbursement of extra research funding through the FP consistently outperforms the disbursement of extra research funding nationally.

Figure 18: Impact of the FP on R&D intensity, 2010-2030



Source: DG Research Data: NEMESIS-bis model

Table 3: 1 euro invested at EU level has more impact than 1 euro invested at national level

	FP disbursement	National disbursement
GDP	0,51	0,27
GDP corrected for quality	0,82	0,35
Extra-European exports	0,73	0,07
Extra-European imports	-0,35	0,21
R&D intensity	0,061	0,058
Research employment	40.440	33.516
Total employment	492.579	428.380

Source: DG Research Data: NEMESIS-bis model

Specific economic impacts

While the aforementioned economic impacts are situated at the aggregate level, it is also possible to list a number of more specific impacts:

- The health sector is a major provider of jobs and wealth in Europe. The pharmaceutical industry in the EU directly employs nearly 600 000 people (including Switzerland) in highly qualified jobs and generates 3 to 4 times more indirect jobs. Research-driven pharmaceutical companies invest up to 15-20% of their sales in R&D, which represents a higher percentage than any other industrial sector. (ie. € 40 billion per annum). In the late 1990s, Europe lost its leading position in pharmaceutical R&D investment to the US, which spent 140 percent of that of Europe in 2002. This gap is still widening. In order to reverse this development, Europe needs a strategic and EU-driven agenda to enhance and accelerate pre-competitive research in sectors identified as bottlenecks for the development of innovative medicines.

- More than 40% of productivity changes in our economies are explained by ICT, which also plays a vital role in meeting growing societal demands, while opening new research avenues in other research domains.

- The development of new environmental technologies in the area of waste processing will allow Europe to reaffirm and maintain its leadership in one of the main high-tech growth industries.

- The development and integration of new and cleaner energy sources and the consequently reduced dependence on oil and natural gas imports, while also generating positive environmental impacts, will reduce the vulnerability of the economy to macroeconomic shocks induced by sudden oil price increases.

- The results of energy research will allow benefiting from energy savings, lower the cost of innovative energy technologies, and demonstrate the feasibility and benefits of the use of renewable energy sources.

- The development of new, more environmentally sustainable and possibly lower priced agricultural inputs will generate benefits for consumers and possibly result in lower production and consumption prices. These effects will be more than proportionate in the new Member States and Candidate Countries, where agriculture still accounts for a sizeable share of the economy.

- High-visibility and credible research on the possible health effects of consuming genetically modified organisms (GMOs) will increase consumer confidence and consumption, and serve as a basis for new manufacturing and services industries (provided that the health effects are at least found to be neutral).

- The development of new materials, which are cheaper to produce, have more optimal intrinsic properties, and are more easily processed and integrated into production, may help European companies to remain competitive, create employment, and avoid having to relocate to low-cost areas.

- The competitiveness of Europe's industries will also be helped by the development of industrial technologies that lead to the more rapid discovery of new materials, allow for a better characterisation of materials, enhance the molecular-level control over their properties, and lead to more robust design and simulation.

- Progress in the field of nanotechnology can result in a larger share of a market that is projected to grow from € 2.5 billion in 2003 to several hundreds of billion per year by 2010.

- The improvement of transportation networks (road, waterways, railroads), by reducing traffic congestion, and while also generating positive environmental benefits, will save time, reduce the cost of road maintenance, and reduce the negative medical fall-out of too much motorised transport (asthma, etc.).

- Maintaining the long-term sustainability of the transportation sector through the development of inter-modal transportation networks will allow for the safeguarding of 10 percent of all European job opportunities and 11 percent of GDP.

- Progress in aeronautics will result in lower aircraft development and operating costs, reducing the price of air travel, with large benefits for consumers. The improvement of air traffic management system will reduce air traffic congestion, produce important environmental benefits and reduce significantly delays and associated costs.

- Aeronautics research will allow Europe to safeguard its leading position in the world market. If a 50 percent share of the market is maintained, the 14.000 new aircraft that will be needed in the next 15 years will bring in € 500 billion in income.

- A competitive aircraft manufacturing sector will support the further development of the air transport sector, which will generate 4 million new jobs by the year 2020, with the direct contribution to GDP increasing from 2.6 to 3.3 percent, or from 10 to 13 percent when both direct and indirect employment are taken into account.

- Improving the development of the space sector in Europe will eliminate risk of technological dependence on other industrial powers in space-related fields, increase the service market share, help to maintain industrial competitiveness and guarantee an increase in employment.

- Studies carried out at the time of the conception of the GALILEO programme indicate that the macro-economic benefits, to be achieved over a 20 year period, amount to € 18 billion.

- Environmental research can enable Europe to reduce the costs of air pollution, amounting to 2 percent of the EU-15's GDP.

- Strengthening the European Research Area in the maritime field will promote European leadership in marine science and technology and the integration of the latter in maritime industry and policy making.

Social impacts of FP7

Social effects of research, while intuitively perceived as being of high importance, are not always immediately and explicitly put forward in the formulation of the research programmes and projects. In general, the 'impact pathways' linking the successful implementation of RTD to the actual achievement of beneficial social changes are not easy to represent and to monitor. However, the review that was carried out at past and present EU research clearly shows that several major areas of potential social impacts are in effect addressed in the work programmes of FPs. Chapter 4, where the impacts of the previous FPs are presented, allows for ascertaining that major societal concerns have been recognised and can be addressed by EU research. However, several challenges still exist.

Through both thematic efforts in diverse areas as e.g. Industrial Technologies, Energy, Transport, ICT, Food and Agriculture, Fisheries, Water Management, Life Sciences etc, as well as through research that directly aims at the advancement of Social Sciences, FP7 can further enhance issues such as health and safety, social cohesion, human capital, well-being, governance, human rights and ethics, self-sufficiency, equity, etc.

For instance:

- Health research can be a major contributor to providing solutions and best practices for improvement of health care. It will also be crucial for meeting the challenges of ageing and increased migration.

- Further European research on ageing may contribute to increased life expectancy and in particular disability-free life expectancy, both social and medical research can contribute to reduce premature mortality (i.e. before the age of 70) improving the indicator of potential years of life lost.

- Currently, 40.000 people die each year on European roads. Transport and IST research may contribute to reduce the number of road accidents thanks to the adoption of safer in-vehicle or road infrastructures technologies.

- Improved mobility and more effective transportation of goods in an enlarged Europe requires the construction of new infrastructure (especially to integrate new Member States), an increase in existing infrastructure capacity through advances in intelligent transport and use of satellite information and the development of smart interactions between vehicles and transport infrastructure.

- An efficient air transport system supports the European integration, reduces congestion (or helps to accommodate future demand) and helps to reduce the environmental impact. Air transport will play a major role in supporting the integration of the New MS as it is a fast means of communication. A safer, more reliable, more secure and affordable air transport will be beneficial for the traveller.

- The improvement of inter-modal transportation networks (road, waterways and railroads), will save time, reduce the cost of road maintenance, and reduce the negative medical fall-out of too much motorised transport (asthma, etc.). An efficient (air) transport system supports the European integration, reduces congestion and helps to accommodate future demand.

- Energy research will contribute to transform the current fossil-fuel based energy economy towards a future more sustainable energy economy based on a broad portfolio of the most appropriate energy sources and carriers. The challenge is to achieve such a transition, over a period of decades without compromising European economic performance and the quality of life of citizens.

- European urban research can help to improve decision-making and by this way the quality of life of citizens leaving in the European towns, reducing amongst other things the use of resources, the levels of crime and enhancing public participation .

- Educational research may influence both future spending on education and the effectiveness of this spending in terms of levels of educational attainment and literacy of the population.

- Bridging the digital divide between old and new MS and between urban and rural areas, notably by ensuring high speed access to all and everywhere, can enhance social cohesion.

- Specific regions (especially rural and peripheral ones) could benefit of satellite communication solutions. With current solutions it is known that 2% of the EU population will never have access to broadband.

- Space-based systems can provide a higher level of security for citizens, allowing, for example, for a better enforcement of border and coastal control and identifying humanitarian crises in their early stages.

- Space sciences in general, and space exploration in particular, push forward the boundaries of human capabilities, give rise to exploration beyond the limits of today's knowledge, and inspire the coming generation.

- Health policy-driven research can be a major contributor to providing solutions and best practices for containing growing health expenditures. In the last 10 years, most of the EU countries have faced an alarming acceleration of their health expenditures. The integration of biomedical and policy-driven research will be crucial to meet the challenge of ageing from an economic point of view.

- Positive social impacts are expected from new developments realised through Nanotechnology in the fields of medicine, electronics, materials, etc.

Environmental impacts of FP7

FP7 will contribute to support the environmental dimension of the Sustainable Development Strategy and of the Lisbon Agenda. If Europe wants to ensure its leading role in environmental policy and technology and wants to respond to society expectations, efforts for environmental research and cross-cutting enabling technologies should substantially increase. This would also contribute to the definition, development and implementation of environment related EU policies.

- *Environmental knowledge:* better understanding of environmental processes will improve natural resources management and the forecasting of environmental processes. In this context, the Global Earth Observation activity will contribute to the protection and management of the Earth System.[203] Furthermore, FP7 will recognise the need for research activities for the analysis of sustainable development, scenario building and impact assessment.

- *Environmental technologies:* Advances in knowledge and innovation will help decoupling economic development from adverse environmental impact and further sharpen the competitive edge of societies which possess the know-how and capacities.

Also cross-cutting enabling technologies, such as nanotechnology, biotechnology and industrial technologies can have a positive environmental impact. For instance:

- *Nanotechnology.* Energy savings are anticipated via nano-technological developments that lead to improved insulation, transport and efficient lighting. The development of nanotechnology-based remediation methods can repair and clean-up environmental damage and pollution (e.g. oil in water and soil). Moreover, with the realisation of “bottom-up” and “molecular” manufacturing, nanotechnology has the potential to reduce waste across the whole life-cycle of products.

- *Biotechnology.* Biotechnology offers the prospects of reductions in raw material and energy consumption, as well as less pollution and recyclable and biodegradable waste, for the same level of industrial production. Further in the area of biotechnology, the use of integrated crop management practices can help reducing the use of pesticides by 50%. Development of innovative biotechnological processes could replace fossil fuels by a whole range of alternative fuels on bio-basis (in addition to “bio-diesel”) as well as on the basis of “blue” (marine) biotechnology.

- *Industrial technologies.* Radical rethinking of production processes could lead to reduced requirements of material inputs, decreased production of waste and reduced emission of nuisances. Advances in eco-efficient engine technology and hybrid/electric vehicles could decrease the contribution to global warming and exhaust emission.

Furthermore, also other areas of research have a positive impact on the environment.

- *Energy.* Within the general context of sustainable development, the main drivers for energy research are security of supply, climate change and economic growth. Current projections show most of the crucial energy indicators to be moving in the wrong direction, in the EU and even more so worldwide – energy consumption increasing 1-2% per year in the EU, fossil fuel dependency increasing, import dependency growing (EU) from 50% today to 70% by 2030, CO2 emissions increasing (more than 2%/year, global). Energy research can help reverse the above ominous trends.

- *Transport.* Innovative car and rail technologies would contribute to reducing the important part of transport in the global pollution, in particular C02 and NOx emissions as well as noise pollution.

- *Space.* Earth observation from space supports sound environmental management and protection by providing basic homogeneous observations with unsurpassed coverage on climate and weather, oceans, fisheries, land and vegetation. Space has enabled a weather prediction over 5 days. A sustainable agricultural model could benefit as well from the use of earth observation tools. Likewise the control of the implementation of the Kyoto protocol will require independent European space capabilities. In addition, earth observation as part of Europe’s GMES capacity and global positioning systems can be employed in a variety of tasks including: protecting soils and managing water resources; monitoring crop development and forecasting food production; providing early warning for flood and fire risk; monitoring the tropical forest; preventing ground-motion hazards; ensuring coastal and maritime monitoring; and forecasting, preventing and managing natural disasters.

- *ICT.* ICT allows for better control of industrial of industrial production processes that improve data integration and standardisation, management and monitoring. ICT could further improve the management of supply chains, leading to less holding of stock and storage requirements, reduced wastage from stocks which become obsolescent or damaged before they get sold.[204]

Concluding remarks

Compared to the zero and business-as-usual options, the proposed FP7 option achieves superior 'ERA' effects and economic impacts. The above sections have clearly demonstrated the superiority of the proposed FP7 option in economic terms over a business-as-usual scenario of moderate FP growth and a hypothetical scenario of a complete discontinuation of the FP without compensation by the EU member states via an increase in national research funding. The results generated by the Némésis-bis econometric model clearly show that - because of higher FP crowding-in and economic multiplier effects – under any scenario that starts from a doubling of funding under FP7, Europe’s economic growth, (research) job creation, export increase, import reduction and R&D intensity will be higher than under either one of the two other scenarios. The best results will be achieved if FP funding continues to grow rapidly also after FP7, while allocating funding to EU member states and sectors on a performance basis also appears to have positive effects.

Suppressing the FP would stop in its tracks the process of building an integrated European Research Area, and would lead to greater fragmentation and inefficiency of research efforts in Europe. Even if the reduction in FP funding was compensated for by an increase in R&D spending on national programmes, € 17 billion scattered across 25 MS is not the same as € 17 billion investment at EU level. Research teams would carry out far fewer projects on a European scale, and would become more dependent on the resources and knowledge available in their own country. Reduced cooperation would have a weakening effect on the transfer of knowledge in the EU (EU funding is increasingly at the origin of much transnational co-authorship and co-invention). Some important fields of S&T would therefore advance more slowly, while some countries may find that their capabilities in particular research fields are declining due to inadequate interaction with top teams located elsewhere. In terms of the coordination of national programmes, Europe would return to the complete fragmentation of the pre-ERA period, with 25 Member States and numerous regions defining their research priorities independently from each other and from the EU. The necessity for EU intervention in research is therefore not in question. All stakeholders consulted during the preparation of FP7 were of the view that the FP should be retained as a vital instrument of EU policy for the knowledge-based economy.

The "business as usual" option involves continuing with the FP as it is currently under FP6, with no change to its budget, structure or thematic content. The advantages of this option would be the following. It would involve no increase in the cost of EU intervention (same budget, and no extra learning costs associated with change). It would establish the basis for the continuation of past FP successes. By retaining the same structure, instruments, priorities, rules etc., it would provide a continuity of approach which would be welcomed by participants. However, the disadvantage of choosing this option is that it would not represent an adequate response to the new challenges facing Europe and the need to introduce improvements in the functioning and orientation of the FP. The Barroso Commission has placed renewed emphasis on the Lisbon objectives. Europe continues to lag behind other world regions in terms of economic and productivity growth and employment creation. While FP6 was devised as an instrument to implement the ERA and has made a positive contribution, to continue with the same FP structure and level of funding would not allow Europe to make sufficiently rapid progress towards the Lisbon goals. The EU now has 25 Member States. Keeping the same budget as for FP6 would result in a greater scattering of EU research effort, which must now be distributed between 25 not 15. It is clear that EU coordinating actions for research will need to grow, and that the FP must be expanded and redesigned to take account of the changing structure of the Union. Outside Europe too the world is changing. Emerging countries such as China and India are beginning to establish themselves as serious global players, and, if anything, competition in world markets is growing. The production and exploitation of knowledge must be at the centre of Europe's strategy to compete in higher value products and services, rather than on the basis of cheap labour, and thus to be able to ensure balanced and sustainable growth. The next FP must respond to these challenges; business as usual will not suffice. Experience of FP6, and the reactions of stakeholders, has shown that there are a number of areas that can be improved: The next FP needs to become more user-friendly. There is an understandable demand from stakeholders to reduce the administrative complexity of the FP, and to make it easier for research teams to apply and to participate. Continuing under FP7 without introducing any significant changes in this regard would lead to the frustration of the EU research community, could act as a barrier to some of those currently discouraged from participating because of the complex processes, and would go against the 'better regulation' impetus towards cutting red tape. The impact of FP on progress towards Lisbon could be enhanced by introducing a reinforced emphasis on project outcomes, their exploitation and the monitoring of results. In other words, FP7 should be more "impact-oriented" than FP6. Similarly, a stronger contribution to competitiveness can be made through measures to stimulate greater industrial participation. For the above reasons, continuing "business as usual" would represent a missed opportunity to respond creatively to new dynamics and new needs, and to reinforce the contribution of EU research actions to the Lisbon strategy.

Chapter 6: Towards an effective, user-friendly management and outcome-oriented new FP7

In recent years, criticisms concerning the management of the Framework Programmes have been levelled, in particular, at the Commission.[205] The so-called *Marimon report* of July 2004, prepared by the panel of high-level experts set up to assess the effectiveness of the new instruments of FP6 represents the latest expression of some of these criticisms.[206] The Commission reply to the Marimon observations indicated that many of its findings were very useful for the identification of areas and means to improve the efficiency and effectiveness of the impact of the Community budget on research and innovation in Europe.[207]

In addition, the results of the stakeholder consultations on FP7 orientations (see chapter 4, section 3), along with the observations made in the Marimon report, convey clear messages. Participants in FP6 projects (as well as other interested parties) clearly indicate their preference for stability and continuity of FP6 instruments, rules, terminology and principles. Their main concern is that the effort required to learn new rules, terminology, and administrative and legal processes consumes valuable time and energy and diverts resources from research activities, leading to delays, increased costs, confusion and frustration. On the other hand, some limited changes have been specifically requested by stakeholders, particularly regarding improvements in the implementation of the programme and relating to the design and execution of certain instruments (such as the funding of Networks of Excellence).

Programme management has been reviewed in order to assure the continued development of effective management systems and to include new activities such as the ERC and Technology Initiatives – as well as taking advantage of the new possibilities offered by executive agencies.

Section 1 of this chapter deals with a review of the means and tools to implement the next FP, in particular with respect to the new objectives proposed for FP7. The issues covered by this assessment address primarily the legal and regulatory framework for FP7, the management aspects for each new initiative, including the instruments to be used. In addition, the contractual and funding aspects including intellectual property or innovation issues, those relating to the evaluation and selection of proposals and the instruments specific to that initiative are analysed. *Section 2* deals with the issues relating to procedures and management. Although FP7 is more "evolution instead of revolution", several new aspects are introduced concerning the monitoring and evaluation system in order to help improve the effectiveness and efficiency of FP implementation. The latter are discussed in detail in *section 3* of this chapter

Section 1: Effective management and appropriate instruments

Effective management

Clearly, "business as usual" would not be a viable option for the management of FP7. Although there has been a demonstrable increase in the productivity of the Commission's scientific officers from one framework programme to the next, this trend alone would not be enough to cope with the increased size and scope of FP7 when compared to previous programmes.

In addition to direct management, the Commission has examined the possibilities to exploit, within FP7, other options that are available for the implementation of Community programmes: principally, implementation by executive agencies, structures created under Articles 169 and 171 of the EC Treaty and shared management with the Member States. Each of these has specific characteristics (see table 5) that may make them particularly adapted to the efficient implementation of some parts of the programme and their careful use could enable the Commission services to manage FP7 whilst maintaining the necessary focus upon their core policy tasks.

Generally, it should be possible to delegate many administrative tasks, not closely linked to policy formulation, to an executive agency. This could include the "upstream" tasks associated with the logistics of proposal reception and evaluation, including inviting and paying expert evaluators. Other tasks, such as financial viability checking and provision of statistics could also be assumed by an agency. For certain areas where the outcome of individual projects is not critical to the shaping of future research policy (such as parts of the Human Resources and Mobility activities and SME-specific support actions), "downstream" activities (contract negotiation and follow up) could also be entrusted to an agency. Although the Commission should retain full responsibility for the evaluation and funding decisions at the highest level for the new scheme of co-funding of national mobility programmes, the detailed implementation of the individual grant schemes under this heading could be passed to the appropriate national or regional bodies.

Direct management by the Commission would have to be retained for those activities most closely linked to research policy and its future developments; for example, the selection and ("downstream") management of collaborative research projects.

For actions deriving from Article 169 (Community participation in national programmes) or Article 171 (joint undertakings or other structures) of the EC Treaty, the management structures will be created by the decisions establishing the actions and would involve a significant proportion of management outside the Commission services; specific management structures would have to be decided on a case-by-case basis according to the characteristics of the action concerned.

Table 4: Characteristics of the various management options available for FP7

Direct Management by Research DGs	*Executive Agency*	*Other Structures*	*Management in association with the Member States*
Direct management is essential where there is a close link between the activity and policy formulation, or where the tasks require discretionary powers in translating political choices into action. Direct management is not essential for tasks that are purely administrative or that could be better managed locally through shared management with the Member States.	Executive agencies may be entrusted with tasks that are required to implement a Community Programme (with the exception of those tasks requiring discretionary powers in translating political choices into action and where feedback from the actions are relevant for policy orientations). Executive agencies are particularly suited to performing administrative tasks in the implementation of a programme; thus freeing Commission staff for the performance of core tasks including policy.	Joint undertakings or other structures for implementing research actions may be set up under Article 171 of the Treaty. The role of the Commission's services within the structure would be decided on a case-by-case basis at the time that the structure is created. Article 169 of the Treaty also foresees the possibility of participating in structures created for the execution of research and development programmes undertaken by several Member States. These structures would involve a significant proportion of management outside of the Commission's services.	Delegation of certain elements of the FP management to public bodies established in the Member States is most appropriate for actions that would benefit from being performed locally, where there are no links between individual grants and policy formulation and where there is sufficient national structural capacity. In the case of Community research, management by such bodies could be considered in cases where the actions involve projects with established participants only in one Member State. Delegated management with the Member States is not appropriate for actions involving multi-national teams, where funds can not be allocated to national programmes or where the policy area is also targeted at non-member states
Direct management should be retained for the major funding decisions and for the project management in the case of collaborative research.	An executive agency could perform many of the "upstream" tasks relating to programme implementation as well as "downstream" tasks in those areas where the outcome of individual projects is not critical to the shaping of future research policy (this could apply to parts of the Human Resources and Mobility activities and SME-specific support actions). An executive agency could provide a suitable vehicle to support the implementation of the European Research Council projects.	Article 169 applies to Community participation in national programmes. Article 171 allows for the creation of joint undertakings or other structures and could be used for the implementation of technology initiatives and for new infrastructure actions.	Detailed implementation of the individual grant scheme for the co-funding of national mobility programmes could be entrusted to the appropriate national or regional bodies.

In the case of the European Research Council (ERC), it is suggested that a scientific "governing" council will ensure oversight of policy and the preparation of procedures (notably peer review) and the work programme. An executive agency would be a suitable structure to support the implementation of ERC projects whilst providing the necessary degree of independence.

Shared management of the Framework Programme with the Member States was not considered because of the limitations both of the Financial Regulation and the very nature of the FP which is open to participation of legal entities from around the world, including the associated countries that make a financial contribution to its operation, and because most actions are carried out by collaborative teams from many countries. Nonetheless, all the alternatives permitted by Article 54.2 of the Financial Regulation for centralised management of programmes have been taken into consideration and each one of these options is proposed for some part of the programme.

Appropriate and user friendly instruments: As mentioned above, stakeholders have underlined their preference for continuity and stability of FP6 instruments, contractual provisions, rules and procedures into FP7 although efforts at simplifying access, use and implementation of the actions must be enhanced. Simply maintaining the status quo is thus not possible. FP7 proposes, therefore, the following approach: the instruments of FP6 are maintained, but improvements are made to ensure more effective and efficient management.

Improved funding mechanisms: this would include changes for *Networks of Excellence* (NoE) and possibly some modifications in the funding of SME specific actions (in particular co-operative research). Other improvements to the instruments and their implementation would include streamlining of some of the contractual requirements (including clearer and simpler reporting requirements, simplifying the technical annexes to grant agreements, clarifying ex-ante requirements for financial viability and risk assessment) and clarifying the use and scope of the instruments.

Adjustment of IPR provisions: The bulk of FP6 contractual and IPR provisions could be maintained. However, some improvements and adjustments to the standard grant agreement are necessary based on the experience gained from the implementation of FP6 contracts, and greater flexibility for pre-existing know-how could be introduced in order to avoid some of the unnecessary misunderstandings that have arisen in some FP6 consortia. The latter could be achieved by allowing contractors to identify only the pre-existing know-how that they propose to provide access to and by underlining that only that pre-existing know-how necessary for the project is required. The use and dissemination of project results during and after the end of the project could be further encouraged, possibly combined with retention of a percentage of the Community financial contribution or systems of financial disincentives if these objectives are not met. An alternative would be an additional bonus to be paid after the end of the project if these objectives are met according to requirements. Any such scheme would have to be discussed in detail with all the Commission services involved.

In addition, special provisions may be necessary for the ERC, technology platforms and new infrastructure support actions.

Implementation of the new initiatives under FP7: Some of the new initiatives proposed for FP7 will require particular attention with respect to the nature of the instruments used, specific IPR issues and certain contractual aspects. In particular the grants to be used for frontier research and other new initiatives will have to be discussed and considered in much more detail by the Commission services and interested parties.

Table 5: Overview of possible procedural and instrumental changes in FP7 by specific programme

SPECIFIC PROGRAMME	EVALUATION & SELECTION	INSTRUMENTS/IPR/CONTRACT
1. PEOPLE	Greater use of two-stage evaluation, use of two-step in one stage for fellowships entirely remote evaluation – possibly including remote panels	Strengthen "Marie Curie" actions by placing emphasis on: attracting young people through support for the structuring of training, in particular inter-disciplinary training; the role and place of women in science and research;- transfer of knowledge, in particular for technologically least advanced regions and SMEs; increased training and mobility exchanges with other parts of the world; life-long learning and career development.
2. IDEAS	Since these often involve teams from a single legal entity, evaluation can be simplified – greater emphasis on scientific criteria, less on management, horizontal aspects, greater emphasis on dissemination potential	Instruments with single partners or fewer partners, no requirement for trans-national collaboration, simplified funding and reporting provisions.
3. COOPERATION	*Collaborative Research:* Greater use of two-stage evaluation greater use of remote evaluation (to the extent possible). It should be better ensured that evaluators with diversified profiles (including regarding IPR and innovation issues) are systematically included in evaluation panels. *Technology Initiatives:* For Article 171 initiatives the process with Parliament/Council has to be initiated and followed-through, for IPs "standard" procedures (unless particular aspects to be included in Guidelines or Rules). It should be ensured that evaluators with diversified profiles (including regarding IPR and innovation issues) are included in evaluation panels. *Coordination of national/regional programmes:* Special provisions for Article 169 actions (ie Council and Parliament); for others, greater emphasis on remote evaluation, no need for anonymity, criteria for evaluation to concentrate on impact of coordination.	*Collaborative Research:* 'Networks of excellence' and 'integrated projects'; 'STREPs', coordination actions, and specific support actions. Funding of networks of excellence to be reviewed. European loan guarantee scheme for large projects. *Technology Platforms:* 'Integrated projects'; Article 171 (requiring a specific management structure), European loan guarantee scheme. *Coordination of national/regional programmes:* Extending ERA-NET activities and their financial support to research activities; Article 169.for use in areas where Member States have firmly displayed willingness to make financial commitments, or to support 'variable-geometry' cooperation between a limited group of Member States, or by means of 'packages' of actions to be agreed upon simultaneously by Council and Parliament, or a 'framework regulation'. Direct support to European intergovernmental research organisations when Europe would benefit from their being conducted at Union level.
4. CAPACITIES	Inclusion of regional/Structural funds component in evaluation criteria for construction of new infrastructure. Co-funding aspects will be important criterion for construction of new infrastructure.	Trans-national access to infrastructures; research projects; support for construction and operation of new infrastructures of European interest using a mechanism like trans-European networks

Section 2: A user-friendly and cost effective FP7

Lessons learnt from past experience: New and better ways of managing research projects should be developed to ensure that participants in FP7 projects can concentrate on the scientific and technical aspects while complying with the basic financial and legal requirements. The Commission has undertaken an important exercise in simplification of regulation. Lessons learned from this exercise will be applied to the new legislative framework (e.g. avoiding repetition between Framework Programme, Specific Programmes and Rules) as well as methods or mechanisms for reducing the administrative burden on participants. A review of administrative, financial and legal provisions under FP6 is being carried out in the context of the Action Plan on Rationalisation and Acceleration. An inter-service Working Group on simplification has been set up to identify improvements in funding, instruments and management for FP7; both of these should help to identify areas for improvement. Some of these aspects are identified here. Certain aspects relating to the principle of "annuality" of budget impose limitations. Removing these restrictions would allow greater flexibility in managing resources, attributing funds to calls for proposals, and funding projects, and some reduction in the burden of risk assessment required by authorising officers. That is, if funds allocated to a project could be re-assigned to the research budget within a period of n+2 for high risk projects that do not meet their goals, there would be no incentive to keep poor to non-performing projects running and major problems could be avoided. Other aspects to be reviewed include the provisions relating to cost models, adaptation of FP7 grant agreements to include recent changes to Financial Regulation implementing rules, roles and responsibilities of participants including the need to review different types of participants, review of fraud-proofing and sanctions, and possible staged implementation of projects and the use of go/no go clauses. In addition to these efforts the Commission has also recently established a Sounding Board to specially take into account the problems specific to smaller actors, such as SMEs and small research institutions for FP7.

Reduction of management costs: Although there is no "administrative burden" to participating in Community-funded RTD actions in the sense of compliance with regulatory or other legal provisions, there are management costs involved in participating. The bulk of these were reimbursed in full under FP6 projects by the EC financial contribution. A comparison on administrative burdens related to the management of participation and rules of procedure between the EU research programmes and those of individual Member States led to nuanced findings.[208] The main conclusion is that although (1) EC rules and procedures tended to be more complex and time-frames longer, it appeared that (2) the managerial costs of EC programmes were not unreasonably high given the nature, size and composition of the consortia participating and that (3) the quality of the EC project appraisal/selection process was high. However, that level of quality has an administrative cost. It is the cost element of the quality-cost equation that the proposed changes are designed to optimize.

A different issue is that of 'internal' administrative burden – that of the cost of administering the FP. Comparison between EC and Member States administration of research programmes indicates that the FP has been among the most cost-effective. Its cost-effectiveness will be further improved under the options discussed here.

Simplification of FP implementation: Further simplification of the implementation of the FP can be achieved by using existing resources better and more effectively, consolidating and revising existing procedures. Thus efficiency will be improved. One of the actions arising from the efforts to rationalise and accelerate FP6 implementation was a review of all documentation required of potential contractors. To the extent that information and documentation requested is superfluous it will be eliminated. Better use of available information by means of data sharing, common IT systems and greater coordination between research Directorates General will result in improvements for participants. Adjustments to the nature and requirements of some of the instruments will also help to streamline the management of research projects both upstream and during their implementation.

Complementary financing from Structural Funds should be allowed in FP7. Financial engineering schemes involving funding by the European Investment Bank (EIB) and national public and private funding will have to be encouraged and further exploited. The feasibility of a European loan guarantee scheme to facilitate financial support (by means of loans) from banks to major technological research projects is being reviewed to leverage private sector funding and facilitate the overall financing of research projects.

A single legislative instrument for the whole FP would enhance the political visibility for the EU's actions in support of research. However, given the two separate adoption procedures under the two Treaties (EC and Euratom) it is likely that two separate FPs will continue to be necessary. Even if the new constitution comes into force before or during the process, this will not have an impact on the number of Framework Programmes if a separate FP is required for Euratom. The number of Specific Programmes and their content will have implications for the number of programme committees, management and coordination between programmes. Certain common elements would have to be assured in each programme and careful coordination of each Decision in Council will be necessary. The advantages of several programmes are specificity, autonomy and visibility of each Specific Programme, however, it would be important to ensure coherence and interchange between the programmes, work programmes etc. It should be proposed that Programme Committees concentrate on policy and programming tasks that would relate mainly to their opinions on work programmes.

Programme Committee approval of project funding should be abolished for all programmes and Committee(s) only be informed of the results of final negotiations between Commission and participants.

As with the FPs, the Rules for Participation would be adopted separately (for EC and Euratom), the former as a Regulation of Parliament and Council for the current EC Treaty and the latter as a Council Regulation under the EEC Treaty. Use and application of Article 9.2 of the FP6 Rules should be reviewed for FP7. The terms and conditions of collective financial responsibility will be reviewed and clarified with respect to its application (including the instruments to which it applies). The eligibility of costs incurred by third parties and the use of third party resources should be reviewed and clarified. Pertinent aspects relating to cost models and funding rules (those not already covered by the FP and SP) could be introduced to the Rules (rather than only in the contract as is the case now). Any particular funding rules (or other aspects) would have to be clarified for particular instruments or parts of the FP. In addition, any special provisions would have to be clearly justified and established in the Rules if it is not possible to introduce necessary changes to the Financial Regulation. Special attention should be paid to clarifying and underlining the provisions of the Euratom Rules and FP.

Section 3: New programme evaluation and monitoring system

The previous chapters have examined the impacts (past and expected) of FP intervention in research and have drawn on evidence provided by programme evaluation and monitoring. The programme and evaluation monitoring system supports policy formulation, accountability and learning and is essential to help improve the effectiveness and efficiency of research programmes' design and implementation. This section outlines why a new system is now required for FP7, and presents its main characteristics. These are consistent with the requirements of the Financial Regulation [Regulation (CE, EURATOM) No 1605/2002 of 23 December 2002].

Why is a new evaluation and monitoring system needed?

FP7 should be a key instrument contributing to the Lisbon, Göteborg and Barcelona objectives. The system for evaluating FP7 must therefore act as a vector for tracking the results of research programmes, how they are contributing to policy goals, and what needs to be improved so that they can be more effective in achieving these goals. This requires a new approach based on clear programme objectives, with associated indicators of outcome and impact.

The ambitious size and scope of FP7, with its bigger budget and new instruments (ERC, technology initiatives), are also arguments for strengthening and adapting the evaluation system.

Another argument relates to the 2002 Better Regulation Package and the communication on impact assessment which have given rise to a new culture at the Commission in which increased attention is paid to improved accountability in terms of results and impacts achieved.

The new FP also provides an opportunity to take account of some lessons learned from the past, and to introduce some important improvements to the system. Two key changes in this regard are the reinforcement of the evidence-base upon which evaluations rely (data, analyses, studies etc.), and the further streamlining of the system, in particular to reduce the administrative burden on participants.

Lessons learned from the past

The FP evaluation system has evolved over the years. However, it has to be acknowledged that all research programme evaluation is difficult because of the uncertainties and risks of research activities, particularly with a multinational programme of the size and scope of the FP. This is the moment therefore to take stock of strengths and weaknesses and to examine how programme evaluation might be better done in the future.

The system has continued to rely on the use of panels of high level independent external experts, and studies by professional evaluators, mostly impact studies through surveys carried out at thematic programme, FP and national levels. Recent years have seen these features integrated through multi-annual programme evaluation exercises such as the Five Year Assessment.

Table 6: Strengths and weaknesses of the Community Research Evaluation system

Community Research Evaluation system	
Strengths	**Weaknesses**
Independence	Lack of consistency, comparability and availability of data
Expert validation of the science	Lack of coherent structure of evaluation indicators and objectives
Project level assessment of user benefits and impacts	Lack of comparability of results - over time, between interventions
Combining strategic and operational levels	Limited coordination between exercises
	Timing and insufficient resources
	Limited impact on decision making

What are the main features of the new evaluation and monitoring system?

The principal characteristics of the new system are:

- It will be more outcome and impact oriented and provide more effective feedback on tangible results and progress towards the overall goals;
- It will be based upon clear and verifiable objectives, with a robust and coherent set of

indicators to monitor achievement. The indicators will be provided at three levels: operational (or management) aspects, outputs, and impacts;

- It will provide a strengthened and high quality evidence base, by means of an improved information system and date collection coordinated with programme management, as well as a reinforced approach to studies and analyses;

- It will provide a strong articulation between ex-ante and ex-post evaluation;

- It will be streamlined and rationalised, notably by lightening the reporting burden on participants and by simplifying in particular the monitoring;

- It will be based on a coordinated approach within the Commission and with Member States levels; and include dialogue with Member States and contacts with best practice at world level;

- It will be resourced at a level commensurate with the challenge and comparable with international norms, taking into account the increase in size of the FP and thereby moving towards the target of 0.5% of overall Framework budget.[209]

Implementing the new system – optimising the policy cycle

The new system would identify clear responsibilities for the central evaluation functions and operational level services. The key elements of the overall system would be:

1. Setting ex ante objectives and appropriate indicators:

Objectives and Indicators

It is proposed that the new FP be built on a robust hierarchy of logically interdependent outcome objectives with a limited number of realistic and appropriate indicators. In defining outcome objectives and indicators, priority should be given to establishing three separate components:

- the starting point or baseline for the change;

- the vision for or expected development of the area for the intervention;

- the role of Community research activities in securing that development.

Indicators should be both quantitative and qualitative and progressive to show the path or direction of changes to be expected, in order to allow for monitoring of progress.

These outcome (impact) objectives and indicators should be complemented by management and output indicators in order to track progress during the lifetime of the research activities. An outline structure for possible objectives and indicators at the three levels, is given in Table 8.

2. Tracking progress, measuring results and evaluating impact – strengthening the evidence base

Data collection and use

It is proposed that better means are found for the systematic and comparable collection of data over time and between activities. Demands on participants should be kept to the necessary minimum. The information collected could where appropriate be complemented by coordinated and targeted exercises based on interviews and survey[210].

It is envisaged that a 'programme evaluation data clearing house' be set up to provide a resource of information on all Community and Member States' research programme evaluations.

In support of the programme evaluation activity it is proposed that more work be carried out on profiling of the applicants, projects, participants and areas of research being addressed. A complementary feature of the work should include the study and profiling of non-participants in Community research. This should be based on centrally collected data for the proposed management system.

Monitoring of implementation (management)

Monitoring of implementation management would be ensured by operational senior management within the Commission on a continuous basis with annual check points and using a common set of management performance indicators. Adequate resource would be given to this process. The annual results of this exercise will be used to inform senior management and as an input to the ex-post assessment exercise.

An interim evaluation by science panels (S&T content)

Interim evaluation of the FP would be carried out by independent scientific panels which would assess the quality of the research activities, progress towards the objectives set and the scientific and technical results achieved. Such an interim evaluation of FP7 (of 7 years duration) would therefore take place 3-4 years after the start. It could be complemented by a similar exercise at the end of the programme to feed into the ex post assessment (see below).

Coordinated studies

A coordinated programme of studies should be developed, for:

- horizontal assessments of such topics as the impact of research on issues such as productivity, competitiveness and employment; structuring effects of the FP on the ERA (fragmentation, excellence, coordination) through the formation and development of commercial and knowledge networks, and the creation and support to infrastructures; and the impact of Community research on strategic decision making in companies and research organisations and national, European and regional authorities;

- assessment of impact and achievements at portfolio, programme and higher levels against the strategic objectives and indicators that are set within a clearly defined programme logic.

Programme evaluation methods to include: sampled analyses, case studies and longitudinal surveys; studies coordinated with Members States; where appropriate, cost-benefit analysis or follow-on macroeconomic impact analysis.

New evaluation research programme

A programme of research projects on the topic of programme evaluation is proposed, in order to:

- develop new programme evaluation tools and approaches and thus allow the development of new programme evaluation expertise and coordination for Europe;

- provide a focus for international collaboration in the field of programme evaluation, which would help to sustain the Community's international leadership in the field.

Ex post evaluation

An independent ex post programme evaluation of an FP would be undertaken within 2 years of its completion. This would be supported by the coherent set of independent studies, interim evaluation (science panels) and other evaluation activities carried out over the life-time of the FP, as listed above. The report of this exercise would be presented to all interested stakeholders, including the Parliament and Council. Furthermore, this report would feed into future ex ante evaluation and impact assessments by the Commission.

3. Preparing the future – integrating impact assessment and ex ante evaluation

Impact assessment

Work on (ex-ante) impact assessment (which will also incorporate information from the ex-ante evaluation required by the Financial Regulation) will be organised at two levels:

(Ex-ante) impact assessment for specific programme areas:

Each specific programme area will be responsible for carrying out work to prepare ex-ante analyses of future policy options in their field. In particular, two years before the next FP proposal, each programme will prepare an impact assessment report for their area, assessing future policy options and their expected impacts. This should help to embed impact assessment more firmly in the policy formulation process.

(Ex-ante) impact assessment for the overall FP:

Work will also be carried out to explore and assess policy options at the overall FP level. This will include efforts to reinforce predictive methods (such as econometric modelling, identifying factors that will be important to productivity and competitiveness, or techniques to better analyse the likely positive and negative social and environmental impacts). Based on this work, and using the results of the above specific programme reports, an overall impact assessment report will be prepared for the next FP.

The articulation between ex-ante impact assessment and ex-post evaluation will also be enhanced, in particular through ensuring the two exercises are timed to feed into each other. Ex-post work will therefore be available in time for the impact assessment of future policy options, and, in turn, the new policy objectives and performance indicators will feed into later ex-post work.

Conclusion

The above sets out principles on how the Commission proposes to ensure programme evaluation in the future. The detailed arrangements will be developed in due course in the light of the reactions to this report and the decision taken by the European Parliament and Council on the 7^{th} FP. This would for example include specific arrangements for evaluating the European Research Council and the Joint Technology Initiatives.

It is the Commission's hope that this overall approach will provide programme evaluation and assessment which will in the future be of even greater utility to all stakeholders in guiding decision making.

Table 7: Objectives and Indicators for the FP7 Specific Programmes and priorities

Programme level	Management objectives and indicators (EC services level)				Outcome objectives and indicators (participant level)	Impact objectives and indicators (EU level)
	Budget execution rate *(%)*	**Time to contract *(Months)***	**Time to payment *(Months)***	**SME participation rate *(%)***	The number of FP generated scientific publications, citations, and their citation impact score; new standards, tools and techniques; patent applications and licence agreements; new products, processes and services; number of people trained through the FP; Amount of energy savings and pollution reduction achieved as a result of FP research; etc.	Assessment at the aggregate FP level: Impact on the achievement of the Lisbon, Göteborg, Barcelona and other objectives. Assessment at the SP or project/participant level: Contribution made to the EU S&T and economic performance (additional turnover, profit, cost savings; number of existing jobs safeguarded or new jobs created; increase in IPR revenues or high-tech exports; etc.)
Specific Programme 1: People (Marie Curie)	X	X	X	X	The total number (at the (sub)programme level) of PhD participations; EU and non-EU researchers attracted (back) to the EU; researchers that have moved from the university to the business enterprise sector; etc. should be X or increase by X%; The average (per project funded) number of scientific publications and other scientific and innovative outcomes should be X (or increase by X%)	The total number of researchers exchanged within Europe, or attracted (back) from outside Europe as a result of the FP should be X (or increase by X%); As a result of the FP the human capital gap should be reduced by X%; As a result of the FP the number of European researchers per 1000 population should reach X
Specific Programme 2: Ideas (ERC)	X	X	X	X	The average (per project funded) number of scientific publications in SCI journals; highly cited publications; participations by young researchers; new tools and techniques; etc. should be X (or increase by X%)	The total number of EU publications (plus their citations and citation impact scores) for publications that can be traced back to the FP should be X (or increase by X%)
Specific Programme 3: Cooperation (Including joint technology initiatives and the part of coordination and international activities to be funded within the priorities)	Weighted average below	Weighted average below	Weighted average below	Weighted average below	*As above*	*As above*
1. Health	X	X	X	X	X	X
2. Food, Agriculture and Biotechnology	X	X	X	X	X	X
3. Information and Communication Technologies	Indicators will be defined when the specific proposal covering ICT research is defined.	However, they may include the following: completion indicator - number of projects administratively closed within 3 months from the end of the contract >80%; time to amendments <90days; time to contract <263 days	X	X	As above, but may include output indicators covering: no of patent, trademark, registered design or other IP protection applications; no of peer-reviews publication co-authored by project partners	As above, but impact indicators may include: Improvements in work-leadership as a result of the projects work – most innovative products or services, or in market share. Benefit to citizens – improved access to services or knowledge; improved access to employment; better working conditions.
4. Nanosciences, Nanotechnologies, Materials and new Production Technologies	X	X	X	X	X	X
5. Energy	X	X	X	X	X	X
6. Environment (including Climate Change)	X	X	X	X	X	X
7. Transport (including Aeronautics)	X	X	X	X	X	X
8. Socio-economic Sciences and the Humanities	X	X	X	X	X	X

9. Security and Space	X	X	6-10	Space: 15 / Security: The Security Preparatory Action witnessed so far an SME participation of 25%. It should be the intention to keep the SMEs involved in at least 15% of Security research in FP7.	Space: As above but with particular emphasis on the following points: a better coordinated European activity /the maintenance of European industrial competitiveness / the possibility to integrate space assets in daily life tools and services / a faster progress towards a harmonised market for space services / standardisation aspects / a better co-ordination on spectrum policy / ensure that SMEs have the opportunity to participate and innovate in the space sector / shape useful guidelines for future public/private financing initiatives / bilateral international agreements / support to technology transfer / attract new generations in space activities / etc. Security: A “Preparatory Action in the field of Security Research” was launched in 2004 (for a period 2004-2006), a first call for proposals was closed on 23 June 2004. Contracts were awarded in the autumn of 2004. The first outcome of the Preparatory Action will be available towards the end of the lifetime of the research activities under the first call for proposals. The lessons learnt will contribute to the preparation Security thematic priority within FP7. Since mission oriented ‘Security’ related research will be a new theme in FP7, it is difficult to assess the exact outcome and return of security research at this stage. Nevertheless, it is expected to soon witness a series of positive outcomes, such as: the increased level of co-operation and co-ordination among EU stakeholders / The reinforcement of the industrial basis / the increased level of inter-operability and cost-efficiency of security systems and infrastructures./ an increase of the cross-fertilisation between the civil and non-civil security-related research fields and of technology transfer / the gradual shaping of a market for security products and services / In a later stage this could be better quantified in numbers of publications, patents, licence agreements, developments of new products, systems and services, trainings.	Space: As above but in particular the contribution that space assets can bring to the following points: economic growth, job creation and industrial and technological competitiveness / sustainable development / a stronger security and defence for all / fighting poverty and aiding development / support to other EU policies like environment, fisheries, agriculture, transports, humanitarian aid, external relations, etc . / raising the level of Europe as an international partner / preserving Europe’s independence in a strategic field / etc. FP7 will be in support of the European Space Programme. That will be prepared in 2005. This programme will define objectives and schedules of space activities. Indicators will be included accordingly. Security: A European Security Research Programme will contribute, e.i., to: building an EU-wide area of Freedom, Security and Justice, as endorsed by The Hague programme / complementing existing national and international security programmes in support of the Common Foreign and Security Policy / the Lisbon objectives creating technological spin-off effects into the commercial market / reinforcing the competitiveness of the security industry / supporting other EU policies such as Health, Transport, Civil Protection, Energy and Environment.
Specific Programme 4: Capacities	Weighted average below	Weighted average below	Weighted average below	Weighted average below	Some of the outcomes presented above plus the number of regulations and/or directives affected by the results	A positive impact on the economic, S&T, environmental and/or social performances of the EU
Research Infrastructures	X	X	X	X	X	**X**
Research for the benefit of SMEs	X	X	X	X	X	**X**
Regions of knowledge	X	X	X	X	The number of regional policy makers participating in mutual exchange activities per approved project; the number of specific policy tools and products generated by supported projects; the number of identified R&D intensive regional clusters involved in the total number of projects; the number of specific policy tools and products generated by the cluster exchange activity	The contribution to the Lisbon and Barcelona objectives at regional level; the number of cooperation agreements for R&D concluded between participating regional authorities; the degree of university and industry involvement at technology based regional development initiatives
Research potential	X	X	X	X	X	**X**
Science in Society	X	X	X	X	X	**X**
Specific activities of international cooperation	X	X	X	X	X	**X**

Appendix 1: The NEMESIS model

Summary of the model

The NEMESIS-model is a large-scale econometric model at the macro- and sectoral levels, which has been built by a European Commission funded consortium of European research institutes. It comprises roughly 70,000 equations. All behavioural equations are econometrically estimated.

The model can be used for several **purposes**, which include the assessment of structural (mainly R&D and environmental) policies; the study of the short- and medium-term consequences of a wide range of economic policies; short- and medium-term forecasting (up to 8 years) at the macro- and sectoral levels; and building long-term baseline scenarios (up to 30 years).

The NEMESIS-model's geographical and sectoral/product **coverage** is wide. The model is of a multi-country nature, covering the EU-15 countries plus Norway. For the time being, other countries are treated as exogenous and grouped into one of ten different world regions. But efforts are now being made to include into the model the new EU Member States, the US and Japan. An effort is also made to make the model applicable to NUTS2 and NUTS3 level for key variables such as production, value-added, investment, R&D and employment. The model also covers 30 production sectors and 27 consumption good categories.

The model is highly **innovative**. Its supply-side block incorporates some properties of new theories of growth, e.g. endogenous R&D decisions, process/product innovations, and technological/knowledge spillovers between sectors and countries. Five types of conversion matrices – for technological transfers, final consumption, investment goods, intermediate consumption, and energy-environment – are used for describing interdependencies between activities. The NEMESIS-model also includes an energy-environment module, which transforms activity indicators from the macro-model at a sectoral level into energy relevant indexes with price effects and pollutants emissions: CO_2, SO_2, NO_x, HFC, PFC and CF_6. Each individual country is linked to others by external trade.

The NEMESIS-model's main **exogenous variables** include assumptions at world level (short- and long-term interest and exchange rates; activity variables; wholesale and commodity prices); demographic assumptions (total population; population structure; labour force); assumptions at national level(short- and long-term interest rates; taxation; government expenditure); and energy-environment assumptions.

The model incorporates a complete specification of the long-term solution in the form of estimated equations, which have long-term restrictions imposed on their parameters. Dynamic equations which embody these long-term properties are estimated by time series econometrics in order to allow the model to provide forecasts. The model is solved simultaneously for all sectors and countries.

Fields where the model can be applied

The NEMESIS-model can be applied in a wide range of fields, which include science; R&D; competition policy; industrial policy and internal market; employment; energy; transport; agriculture and fisheries; enlargement; employment and social policy; taxation; external relations; environment and health protection; etc.

Track record of the model

The model has a good track record. It has been used for numerous policy analysis for French institutions (Ministry of Environment, ADEME, SENAT, Chambre de Commerce et d'Industrie de Paris), international Institutions (OECD) and the European Union (for example to make an assessment of the 3 % RTD objective)

Website and References:

More information on NEMESIS can be found on: http://www.nemesis-model.net

Fougeyrollas, A., Le Mouël P., Zagamé P. (2002), The NEMESIS model: New Econometric Model for Environment and Sustainable development Implementation Strategies, ECOMOD, Brussels.

Brécard, D., Chevallier C., Fougeyrollas, A., Le Mouël P., Zagamé P. (2004), A 3 % R&D effort in Europe in 2010: an analysis of the consequences, using the Nemesis model. (http://europa.eu.int/comm/research/era/3pct/conference17032004_en.html).

OECD (2004), Environment and Employment: an Assessment. (http://www.oecd.org/dataoecd/13/44/31951962.pdf).

Table on assumptions of NEMESIS-bis Model

	FP funding growth rate 2007-2010	FP funding growth rate 2011-2030	Allocation of FP funding to EU Member States and sectors	Allocation of FP funding to basic and applied research	FP funding crowding-in/out factor	National research funding crowding-in/out factor	Multiplier (Bèta)
Reference scenario 1	3.87 percent	3.87 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	1,1	1	FP funding and national research funding same Bèta
Grandfathering	Doubling	3.87 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	1,1	1	FP funding and national research funding same Bèta
Performance	Doubling	3.87 percent	Publication and patent performance	60 for applied, 40 for basic	1,4	1	FP funding and national research funding same Bèta
Voluntarist	Doubling	11.61 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	1,1	1	FP funding and national research funding same Bèta
Renationalisation, no compensation, reversibility	3.87 percent	3.87 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	-2,1	1	FP funding and national research funding same Bèta
Renationalisation, no compensation, irreversibility	3.87 percent	3.87 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	-1	1	FP funding and national research funding same Bèta
Renationalisation, partial compensation, reversibility	3.87 percent	3.87 percent	Share of each MS and sector in European R&D expenditure	60 for applied, 40 for basic	-1,1	1	FP funding and national research funding same Bèta
Reference scenario 2	3.87 percent	3.87 percent	FP6	60 for applied, 40 for basic	1,1	1	Bèta higher for FP funding than for national research funding
Doubling	Doubling	3.87 percent	FP6	60 for applied, 40 for basic	1,1	1	Bèta higher for FP funding than for national research funding
Voluntarist2	Doubling	7.74 percent	FP6	60 for applied, 40 for basic	1,1	1	Bèta higher for FP funding than for national research funding
Renationalisation, complete compensation	Doubling	3.87 percent	FP6	60 for applied, 40 for basic	1,1	1	Bèta higher for FP funding than for national research funding

Notes and bibliographical references

Part I

1 The 2001 White Paper on European Governance (COM(2001) 428 final, Brussels, 25.7.2001) and the recommendations of the Mandelkern Group on Better Regulation (Final Report, 13 November 2001) helped to further shape these ideas and the Laeken and Göteborg councils gave the political impetus which led to the emergence in 2002 of the so-called “Better Regulation Package”. As well as a Communication on Impact Assessment (COM(2002) 276 final, Brussels, 5.6.2002), the package contained a Communication on Better Lawmaking (COM(2002) 275 final, Brussels, 5.6.2002), an action plan titled "Simplifying and improving the regulatory environment" (COM(2002) 278 final, Brussels, 5.6.2002) and proposals for general principles and minimum standards for consultation (COM(2002) 704 final, Brussels, 11.12.2002).
2 Report “Assessing the Socio-economic Impacts of the Framework Programme”, June 2002. Consortium led by PREST.
3 Speech by José Manuel Barroso, Plenary session of the European Parliament, Strasbourg, 17 November 2004.
4 Angus Maddison, The World Economy: A Millenial Perspective, Development Centre Studies, Paris: OECD, 2001.
5 International Monetary Fund (IMF), Euro Area Policies, Prepared by the European Department, July 2, 2004, p. 10.
6 (Sapir Report) An Agenda for a Growing Europe. Making the EU Economic System Deliver. Report of an Independent High-Level Study Group, July 2003 pp. 27-28.
7 European Commission, The EU Economy: 2002 Review, European Economy No 6/2002, p. 207.
8 Paraskevas Caracostas and Ugur Muldur, Society - The Endless Frontier, EC, OPOCE, EUR 17655, 1997, pp. 94-95.
9 European Commission, Competitiveness Report 2004, p. 7.
10 International Monetary Fund (IMF), Euro Area Policies, Prepared by the European Department, July 2, 2004, p. 14.
11 Mary O’Mahony and Bart van Ark (Ed.), EU productivity and competitiveness: An industry perspective – Can Europe resume the catching-up process?, European Communities, 2003.
12 CEPII-CIREM, European Consortium for Trade Policy Analysis (ECTA), L’insertion de l’industrie européenne dans la Division Internationale du Travail: situation et perspectives, Rapport realise pour la Direction Générale du Commerce de la Commission européenne, juillet 2004.
13 Study carried out in 2004 by Archstone Consulting and Duke University Centre for International Business, Education and Research (CIBER) – www.archstoneconsulting.com.
14 See Chapter 5, Section 3.
15 European Commission, Competitiveness Report 2001, p. 9.
16 International Monetary Fund (IMF), Euro Area Policies, Prepared by the European Department, July 2, 2004, p. 14.
17 International Monetary Fund (IMF), Euro Area Policies, Prepared by the European Department, July 2, 2004, p. 14.
18 European Commission, Action for employment in Europe: A confidence pact, CSE(96)final, EU Bulletin 6-1996, Supplement 4/96.
19 (Kok Report) Facing the Challenge. The Lisbon Strategy for Growth and Development. Report from the High Level Group Chaired by Wim Kok, November 2004; (Sapir Report) An Agenda for a Growing Europe. Making the EU Economic System Deliver. Report of an Independent High-Level Study Group established on the initiative of the President of the European Commission, July 2003; (Strauss-Kahn Report) Construire l’Europe politique. 50 propositions pour l’Europe de demain. Dominique Strauss-Kahn. Président de la Table Ronde “Un projet durable pour l’Europe de demain” établie à l’initative du Président de la Commission européenne. Rapporteur Olivier Ferrand, Avril 2004; HM Treasury, Meeting the challenge: Economic Reform in Europe, February 2003.
20 European Parliament – Committee on Industry, Research and Energy – Rapporteur Pia Elda Locatelli, Working document on science and technology, the key to Europe’s future – Guidelines for future European Union policy to support research [COM(2004) 454].
21 Useful literature overviews include Rachel Griffith, How important is business R&D for economic growth and should the government subsidise it?
22 Austrian Research and Technology Report 2004, p. 2.
23 Ben Martin, Ammon Salter, et alii. The relationship between publicly funded basic research and economic performance. A SPRU Review. Report prepared for HM Treasury, July 1996, p. vii.
24 European Commission, Human capital in a global and knowledge-based economy – Final report. Luxembourg: Office for Official Publications of the European Commission, p. 14-15.
25 European Commission, European Employment Report 2004, p. 77.
26 European Commission, European Employment Report 2004, p. 80.
27 European Commission, European Employment Report 2003, p. 42.
28 See the analysis in Tabellini, G. and Wyplosz, C., “Réformes structurelles et coordination en Europe”, Conseil d’Analyse Economique, Paris 2004.
29 Sustainable development is a framework comprising more than just the environmental dimension, and requiring to analyse and acknowledge inter-linkages and trade-offs. It underpins the whole of this Impact Assessment undertaking. The foregrounding of three dimensions – economic, social, and environmental – is both a boon and a drawback, as it could lead to the threefold segmentation (or the ignoring) of cross-cutting issues. Energy is one such interesting case of an issue area extending beyond the environmental dimension alone (also economic, social, and indeed 'strategic' in different ways) and where S&T play a key role.
30 Biamonte and Olson, 2004, "New global agenda: an analysis of major overview studies of the global environment", a White paper prepared for Foresight and Governance project, Woodrow Wilson International Center for Scholars (Washington, Institute for alternative futures).
31 Brussels, 15.5.2001, COM(2001)264 final, Communication from the Commission “A Sustainable Europe for a BetterWorld: A European Union Strategy for Sustainable Development”
32 Godard Space Study Institute - NASA, US.
33 From 1950 population has more than doubled creating pressures on resources for instance on water resources that passed from 1300 to 4200 millions tons and fish catch that passed from 19 to 91 millions tons.
34 This was demonstrated by a number of FP-funded projects In particular, GARP II funded under FP4 and GREENSENSE funded under FP5 applied the ExternE methodology to the calculation of national damage accounts.
35 Conseil d'analyse économique (D. Bureau, M. Mougeot, et al), Politiques environnementales et compétitivité, la Documentation française, 2004. Fraunhofer Institute Systems and Innovation research (Knut Blind et al), New products and services: Analysis of regulations shaping new markets, 2004.
36 As discussed in the Commission's communication on Innovation policy: updating the Union's approach in the context of the Lisbon strategy, COM(2003) 112 final.

37 Commission's communication on Stimulating Technologies for Sustainable Development: An Environmental Technologies Action Plan for the European Union, COM(2004) 38 final.
38 Available, respectively, at: http://www.rivm.nl/en/milieu/internationaal/Towards_a_more_sustainable_EU.jsp, for the September 2004 report for the Dutch Presidency and Environment Ministry 'Towards a more sustainable EU: the need for investments that benefit economy and environment alike', and and http://europa.eu.int/comm/lisbon_strategy/pdf/2004-1866-EN-complet.pdf for the Kok report.
39 For a prospective state of play, see the December 2004 study of the European Environment Agency, 'Greenhouse gas emission trends and projections in Europe 2004', available at http://reports.eea.eu.int/eea_report_2004_5/en
40 OECD & IEA, World Energy Outlook, 2004.
41 It goes without saying that this section can only provide a flavour of these challenges without claiming to be exhaustive. For an attempt at a comprehensive list of societal impact areas, see http://europa.eu.int/comm/secretariat_general/impact/docs/imp_ass_tech_anx_en.pdf
42 EUROSTAT; the at-risk-of-poverty threshold is fixed, for each country, at 60% of the national median equivalised income. The focus is therefore on the relative rather than the absolute risk of poverty, i.e. this risk is defined in relation to the general level of prosperity in each country and is expressed on the basis of a central value of the income distribution.
43 To name a few: The State of the World’s Children 2005, UNICEF. World Development Report 2000/2001, World Bank.
44 Per capita income in countries with a literacy rate less than 55 percent averages about $600 whereas per capita income in countries with a literacy rate between 55 and 84 percent is $2,400. Source: World Development Report 2000/2001, World Bank.
45 World Development Report 2000/2001, World Bank
46 The International S&T cooperation with third countries (INCO) is one of those programmes which have developed around the idea that poverty can be overcome by successfully developing human and institutional resources.
47 The State of the World’s Children 2005, UNICEF
48 On the relationship between poverty and poor health conditions, see Jeffrey D. Sachs, Investing in Health for Economic Development, 2002 (http://www.project-syndicate.org). Another example: malaria accounts for ca 3% of the global disease burden but attracts just 0.16% of R&D outlays in biomedical research, largely because most malaria victims are impoverished and ignored by industry.
49 The EDCTP initiative within the legal frame of art. 169 TEC unites and coordinates Europe’s clinical trial activities targeted at interventions for use in developing countries. See COM(2001)96.
50 UNAIDS 2004 Report on the global AIDS epidemic 2004, p. 23.
51 Marcia Angell, The truth about Drug Companies, in: The New York Review, Volume 51/12, 25/07/2004.
52 Health expenditure represents ca 9-10% GDP in DE, FR and Scandinavian countries, ca 7.5% in UK, IT and ES and much less in the new Member States (~1.6%). OECD Health Data 2004**,** 1st edition, June 2004.
53 National Audit Office Report (HC 1026, 2003-04): Welfare to Work: Tackling the barriers to the employment of older people, Part I, table 18, p. 30.
54 International Development Research Centre (Gaston Zongo), 2001, Information and Communication Technologies for Development in Africa: Trends and Overview. United Nations Research Institute for Social Development (Olivier Sagna), 2000, Les technologies de l’information et de la communication et le développement social au Sénégal: un état des lieux.
55 European Foundation for the Improvement of Living and Working Conditions & PREST (Manchester Business School), 2004, The knowledge society Delphi: EUFORIA Project Report.
56 Strategic Support Unit (Office of the Deputy Prime Minister, UK), 2004, Engaging the community in e-government. DG JRC - Institute for Prospective Technological Studies (C. Centeno, R. van Bavel and J.C. Burgelman), 2004, eGovernment in the EU in the next decade: Vision and key challenges.
57 As surveyed in: DG INFSO (Elina Zicmane), 2004, Impact of ICT on Sustainable Development.
58 DG JRC-IPTS, Overall impact of FP7 on Europe’s economy and society, November 2004.
59 See the report of the High Level Expert Group on Foresighting the New Technology Wave, “Converging Technologies – Shaping the Future of European Societies”, 2004 (available at http://europa.eu.int/comm/research/conferences/2004/ntw/pdf/final_report_en.pdf).
60 Susan Greenfield, “Science in the 21st century “, Millennium Lectures, 1999.
61 See “BioSystemics synthesis“, Science and Technology Foresight Pilot Project, STFPP Research Report #4, National Research Council of Canada, June 2003.
62 For example, OECD’s Science, Technology and Industry Outlook and STI Scoreboard, US National Science Foundation’s Science and Engineering Indicators, OST’s Indicateurs de sciences et de technologies, UK Treasury/ DTI/ Dept. of Education: Science & innovation investment framework 2004-2014.
63 European Commission, 2004, The costs of non-Lisbon , Executive summary, DG Ecfin, 2004, p3.
64 See for example the conclusions of the Lisbon and Barcelona Councils.
65 The data cited in this section come from latest Eurostat and OECD official statistics.
66 Source: Eurostat Newcronos database - GBAORD data.
67 Pouillot D and Puissochet A, ‘R&D Spending on ICT’. Communications & Strategies no 48, 4th quarter 2002. Quoted from the Interim Report of the 5 Year Assessment on RTD in IST 1999-2003. June 2004
68 Joint Statement of John W. Snow, Secretary of the Treasury, and Joshua B. Bolten, Director of the Office of Management and Budget, on Budget Results for Fiscal Year 2004.
69 David A. King, “The scientific impact of nations”, Nature, Vol. 430, 15 July 2004.
70 Triadic patents relate to inventions patented at all three major patent offices: the European Patent Office, the US Patents and Trademarks Office and the Japanese Patent Office. It is thought that such patents are likely to be associated with a higher expected commercial return, since it is costly to patent in three different patent systems.
71 It is of course to be expected that, due to “a home advantage”, European inventors tend to apply for more patents in their own system (EPO) than does the US, and that US inventors tend to apply more than the Europeans at the US patent office (USPTO).
72 Facing the challenge: The Lisbon strategy for growth and employment, Report from the High Level Group chaired by Wim Kok, November 2004.
73 Four EU Presidencies Statement on Enhancing Europe’s Competitiveness, 2004, signed by Mary Harney (Tanaiste and Minister for Enterprise Trade and Employment, Ireland), Laurens Jan Brinkhorst (Minister of Economic Affairs, Netherlands), Henri Grethen (Minister of the Economy, Luxembourg) and Patricia Hewitt (Secretary of State for Trade and Industry, UK).
74 For an industry view on this see, for example, UNICE Message to the European Institutions 2004-2009, where they state that “successful research and innovation could quite possibly make the largest contribution towards improving Europe’s competitiveness”.
75 See, for example, the discussion in 'Overcoming the European Paradox' 28th February 2002 from UK Prime Minister Tony Blair and Dutch Prime Minister Wim Kok to Prime Minister Aznar of Spain, ahead of the Barcelona Summit.
76 CEPII-CIREM, “European industry’s place in the international division of labour”, Report prepared for DG Trade of the European Commission, July 2004.

77 The World Investment Report 2003. FDI Policies for Development: National and International Perspectives; FT Business FDI, 05/01/2004 http://www.fdimagazine.com/news/fullstory.php/aid/546.
78 The outflow from the US/Japan to the EU increased from 2000 to 2001. See Key Figures 2003, p. 31f. To be noted that the EU investment in the US even exceeded the flow of intra MS R&D investment in 2001 (€ 15 399 million versus € 13 644 million).
79 Highly skilled workers on intra-company transfers and with H -1 B visa (a visa for workers with special skills such as IT. Results are from an excellent pioneering study in this area entitled " Brain Drain - Emigration Flows for Qualified Scientists" carried out under the leadership of Luc Soete and Wendy Hansen, 2003, downloadable from http://www.cordis.lu/indicators/publications.htm. The Canadian example analysed in this study illustrates the high education of EU immigrants: In 2002, most were in S&T occupations including management, natural sciences, social sciences and education.
80 Representing an increase from 49% in 1990 to 73% in 1999. Third Report on S&T Indicators 2003, page 227.
81 Third Report on S&T Indicators 2003, page 232.
82 Such as the initiative for a European Researchers' Charter and the Code of conduct for the recruitment of Researchers. The European Researchers' Mobility Portal (mobility assistance, vacant jobs) and the ERA MORE network of Mobility Centres were launched in 2003.
83 See Commission proposal for a Directive and two Recommendations on facilitating entry conditions of 3rd country researchers into the EU (COM(2004)178).
84 Co-publications within the EU 15 have high shares. Third Report on S&T Indicators 2003, page 304f.
85 EFTA share of 64% or Israel/South Africa of 50% respectively. A larger share of scientific publications is internationally co-authored in the EU 15 than in the US (24% in the EU-15 compared to 22% in the US). Third Report on S&T Indicators, 2003, pages 300ff.
86 Which is probably due to expectations of legal problems. For data, see Third Report on S&T Indicators, 2003, pages 347-349.
87 In the areas of ICT and biotech, the percentages are 7% versus 11% with regard to the US, but higher than Japan (3%). S&T Key Figures 2003, page 71.
88 However, the legal framework alone is not sufficient, so long as those involved in the production of knowledge do not have the know-how to manage IPR properly. EPO's studies reveal that Europeans use patent information facilities less than Americans. EPO concludes that "Europe would…do well to introduce policies which would lead to greater awareness and utilisation of the patent system, thereby establishing a stronger patent culture in Europe." (Letter from EPO Vice President Desantes to Research Commissioner Michel of Oct.2004; http://www.european-patent- office.org/news/info/survey2003/index.phg.)).
89 Provisional figures of the R&D investment Snapshot, European Commission, DG RTD, September 2004 http://europa.eu.int/comm/research/era/3pct/pdf/rd_investment_snapshot_24sep04.pdf.
90 UK DTI R&D scoreboard 2003.
91 DTI R&D Scoreboard 2003. The following figures illustrate this further: Firstly, in the US, federal funding for basic research increased by 26% from 2001 to 2005 (i.e. 6% per year). Federal funding for the National Science Foundation increased by 30 % to US$ 5.7 billion over the same period. Secondly, US federally funded nanotechnology and information technology R&D, both of which have the potential to bring about 'radical' innovation, increased to US$ 1 billion and US$ 2 billion respectively.
92 The public research base and its links with industry; SMEs and research; Fiscal measures for research; IPR and research; Public research spending and policy mixes.
93 Alesina, A. et al. (2003), The size of nations, Massachusetts.
94 Gregory Tassey (2004), "Policy Issues for R&D Investment in a Knowledge-Based Economy", In: Journal of Technology Transfer, 29, pp. 153-185.
95 William J. Baumol (2002), The Free-Market Innovation Machine. Analyzing The Growth Miracle Of Capitalism, Princeton and Oxford: Princeton University Press.
96 William J. Baumol (2002), The Free-Market Innovation Machine. Analyzing The Growth Miracle Of Capitalism, Princeton and Oxford: Princeton University Press.
97 Michael Kremer (2000), Creating Markets for New Vaccines Part I: Rationale, Part II Design Issues, NBER Working Papers
98 Richard R. Nelson (Ed) (1993), National innovation systems. A comparative analysis, New York and London: Oxford University Press.
99 Technopolis (2001), An International Review of Methods to Measure Relative Effectiveness of Technology Policy, Final Report.
100 Technopolis (2004), Policy Instruments for Sustainable Innovation.
101 European Commission (2003), Third European Report on Science & Technology Indicators. Luxembourg: Office for Official Publications of the European Communities.
102 European Commission (2003), Raising EU R&D intensity – Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development – Direct Measures, Report to the European Commission by an Independent Expert Group.
103 European Commission (2003), Raising EU R&D intensity – Improving the Effectiveness of Public Support Mechanisms for Private Sector Research and Development – Direct Measures, Report to the European Commission by an Independent Expert Group.
104 Georghiou L. et al. (2004), 'Making the Difference' – The Evaluation of 'Behavioural Additionality' of R&D Subsidies, Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT), IWT Studies.
105 Rye M., Evaluating the impact of public support on commercial research and development projects, Evaluation, 2002, Vol. 8(2), pp. 227-248; Issues in the design and implementation of an R&D Tax credit for UK firms, IFS; García-Quevedo J., Do Public Subsidies Complement Business R&D? A Meta-Analysis of the Econometric Evidence, KYKLOS, 57, 1, pp. 87-102.
106 For example, in pharmaceuticals, studies put the cost of researching and developing a new chemical entity (NCE) at euro 895 million. Research is also highly risky: on average, only one out of 5,000 to 10,000 promising substances will survive extensive testing in the R&D phase to become approved as a quality, safe and efficient marketable product. (European Foundation of Pharmaceutical Industries and Associations (http://www.efpia.org/).
107 See Goolsbee A. (1998), Does Government R&D Policy Mainly Benefit Scientists and Engineers?, American Economic Review, May, pp. 198 – 202: Federal funded R&D has no significant effect on occupations which receive little federal R&D funding, but has a major impact on salaries in sectors which benefit the most of federal R&D support. Instead of funding new inventive activities, the federal government subsidizes human capital and crowds out private spending by raising wages.
108 European Foundation of Pharmaceutical Industries and Associations (http://www.efpia.org/).

Part II

109 The EC Framework Programme (art. 166 TEC) is the medium-term planning instrument for Community RTD policy. In it are determined both the S&T objectives and the respective priorities for a four-year term. As the EU's main instrument for research funding, it defines the financial scope of Community activity. The activities in the context of the FP are elaborated in detail by Specific Programmes (art. 166.3 TEC) which are implemented by separate working programmes. Proposed by the Commission and adopted by Council and Parliament in co-decision (art. 251 TEC), the FP is open to all public and private entities, large or small.
110 Euratom Treaty, art. 4-11; ECSC Treaty, art. 55 (coal and steel) and art. 41 (agriculture). On this basis, small programmes in fields such as environment, ICT and medical research were conducted.

111 Adopted without an explicit legal basis. It was based on article 235 TEC (now art. 308 TEC), giving the Council the possibility to initiate activities in the context of the internal market, on the basis of a Commission proposal and after consultation of the European Parliament.
112 Title VI, art. 130 F-Q. In the Nice Treaty, they are corresponding with art. 163-173 (OJ C 325 of 24.12.2002).
113 Treaty establishing a Constitution for Europe: art. III-248/251 (OJ C 310 of 16.12.2004).
114 This represents a nominal increase of 17% from FP5.
115 European Commission R&D appropriations (including JRC) as % of total (civil) EU-15 government appropriations for R&D (2002). In order to be able to make a proper comparison of expenditure under the Framework Programme with that of the Member States, only that part of the FPs' budgets that would be classified strictly as R&D expenditure is taken into consideration. The actual total budgets of the FPs are some 20% higher than this with the additional money being spent primarily on training, dissemination and innovation activities together with administration.
116 §5 of the Court of Auditors Special Report No 1/2004 on the management of indirect RTD actions under the fifth framework programme for research and technological development (1998 to 2002), together with the Commission's replies (OJ C 99/2004). This calculation is based on a study undertaken by the 'Koordinierungsstelle EG der Wissenschaftsorganisationen (KOWI), R&D project funding in the EU – governmental investments in EU Members States in the year 2000, April 2002.
117 Mainly with regard to research at the frontiers of science. Following the introduction and success of the Future Emerging Technologies programme in IST, FP6 introduced a broader cross-domain approach, the activity on New and Emerging Science and Technologies (NEST).
118 Key Figures 2002, page 22.
119 In FP6, this is also due to the new instruments.
120 17 % in STREPs and 13 % in Integrated Projects. It is expected that various measures being implemented will increase SME funding, bringing it closer to or above the 15% target.
121 Report of a High-level Expert Panel chaired by Professor Ramon Marimon: "Evaluation of the effectiveness of the New Instruments of Framework Programme VI".
122 Based on internal calculations by Directorate A of DG Research, European Commission, concerning the multiplier effect of FP5 and FP6 funding.
123 Five Year Assessment Five-Year Assessment Of The European Union Research Framework Programmes 1999-2003, December 2004.
124 The INCO programme focuses on countries from Latin America, Asia, and Africa, the Mediterranean countries, the Western Balkans and the Newly Independent States of the former Soviet Union.
125 EUR 20229, "Fusion energy – Moving forward", 2003.
126 except for Belgium and Austria; Indicateurs de Sciences et de Technologies. Rapport de l'Observatoire des Sciences et des Techniques (OST), 2004.
127 Wolfgang Glänzel (2001), National characteristics in international scientific co-authorship relations, In: Scientometrics, Vol. 51, No. 1, 69-115; Isabel Gómez and M. T. Fernandez, Collaboration patterns of Spanish scientific publications in different research areas and disciplines; W. Glänzel, A. Schubert and H.-J. Czerwon (1999), A bibliometric analysis of international scientific cooperation of the European Union (1985-1995), In: Scientometrics, Vol. 45, No. 2, 185-202.
128 These figures result from questionnaire responses received from 2,275 participants in the Third and Fourth Framework Programme. Responses coming from universities and research organisations: 57%; from industry: 38%; from other organisations: 4%. Source: Five-Year Assessment of the European Research and Technological Development Programmes, 1995-1999. Report of the Independent Expert Panel chaired by Joan Majó. July 2000.
129 The figures are based on a survey of FP4 participants carried out for the Five Year Assessment (1999-2003). 2000 replies were received.
130 Involved in the project were 32 partners from 9 Member States, including 5 new Member States, and 3 non Member States.
131 The profiles of SMEs that participate in the FPs differ with respect to their research intensity and size, yet the size of an SME does not seem to be an obstacle for participating in the FPs: in FP5 the share between micro (1-10 employees), small (11-50) and medium-sized (51-250 employees) enterprises was balanced. According to the EURAB WG9 on SMEs, a small number of SMEs, less than 3%, is involved in leading-edge research. However, some 30% of SMEs regularly develop, apply or acquire technology, a number of the order of three million enterprises in EU-15.
132 Carried out for DG BUDGET, Strategic evaluation of Financial Assistance Schemes to SMEs, December 2003, carried out by Deloitte & Touche. The number of applications for funding, submitted by SMEs of all sizes, also increased substantially. For instance, energy research where participation of the industrial sector, SMEs included, rose from 35% under FP4 to 55% under FP6 (1st Call). Also Healthcare Biotechnology research projects demonstrate a similar increase: from 18% industry participation under FP5 (of which 53% from SME and 47% big industries) to 23% under FP6 (of which 83% are from SME and 17% are from large industries). Overall, participation of SMEs in FP6 funded projects has as good as reached the overall target of 15%. Data are provided by Directorate M of DG Research.
133 Harmut Michel: Nobel Prize Winner 1998, Chemistry; Christianne Nusslein-Volhard, 1995 Physiology or Medicine; Rolf Zinkernagel, 1996 Physiology or Medicine; John E. Walker, 1997 Chemistry; Tim Hunt, 2001 Physiology or Medicine; Kurt Wüthrich 2002, Chemistry.
134 such as Neuron, Nature, Nature Cell biology, Nature Neuroscience, TRENDS in Neuroscience, TRENDS in Cell Biology, Molecular Cell, Journal of Neuroscience, PNAS, etc.
135 http://ftp.cordis.lu/pub/science-society/docs/descartes/rap_201103_en.pdf
136 Five-Year Assessment of the European Research and Technological Development Programmes, 1995-1999. Report of the Independent Expert Panel chaired by Joan Majó. July 2000.
137 EUR 20876/1. Clean, Safe and efficient energy for Europe. Impact assessment of non-nuclear energy projects implemented under the 4FP.
138 Analysis made on 313 projects extracted from the FP5"Quality and life" programme and not only restricted to the 49 projects funded under the action line " Research into genome and diseases of genetic origin".
139 Research and Technology Development in Information Society Technologies, Five-Year Assessment (1999-2003), Interim Panel Report, June 2004.
140 In the CIS-3 survey, organisations are defined as 'innovative' when they had either introduced a product or process innovation in the course of the past three years, or had engaged in innovation, but had not (yet) completed or abandoned it. They were asked whether they had received EU funding in general and FP funding more specifically. This made it possible to look for a relation between the receipt of FP funding and other variables such as the degree of innovativeness, the likelihood to apply for a patent, the likelihood to hold a patent, and the likelihood to cooperate with other partners in the innovation process.
141 Even when causality is assumed, it is not clear in which direction causality is operating: does the FP attract more innovative participants or do companies become more innovative as a result of FP participation?
142 Interesting results emerged from an analysis performed on 125 Technology Implementation Plans of CRAFT projects funded under FP5: 73% of the projects anticipated producing one or more product innovations just after the project and 80% expected to develop one or more products also in the future.

143 "Targeted Review of Added Value Provided by International R&D Programmes", UK Office of Science and Technology, May 2004. The study uses the model developed at the OECD by Guellec and van Pottelsberghe and which is presented in the following two papers: (i) Guellec D. and van Pottelsberghe B. (2000), R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries, STI Working Papers 2001/3; (ii) Guellec D. and van Pottelsberghe B. (2004), (2004): "From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter?," Oxford Bulletin of Economics and Statistics, 66(3), 353–378.
144 Epigenetic research redefines heredity. Its implications for human biology and disease, including stem cells, cancer and ageing are far reaching.
145 More than 3.000 links are loaded, hundreds of research organisations are registered on the Job Data-Base, some 2000 researchers' CVs stored and job vacancies are published daily on the Portal.
146 1,6 billion (respectively € 1,87 billion out of almost 19 billion (budget after enlargement, incl. contribution from Associated Countries).
147 As recorded in meetings of working groups (Steering group, External Advisory Group, Programme committee, etc) representing all categories of actors (public bodies, research centres, industry, MS and Associated Countries etc.). The 2004 conference "Europe of Knowledge 2020" stressed the importance of the HRM programme and MC Actions as a fundamental instrument to promote mobility in Europe and to enhance its attractiveness.
148 To date, 55 projects have been funded of a total of € 75 million. On average, 12 entities participate in an ERA-NET, there are roughly twice as many proposals as available funds, and every Member State is participating in several projects. Themes of ERA-NETs are various, covering SMEs, international cooperation, medical aspects, environment, natural hazards, ICT, energy, basic research food, biotechnologies, social sciences, transport etc.
149 Baseline study to identify the technological capabilities of the aeronautical sector in the EU-15 and in three New Member States. Technopolis, May 2004.
150 E.g. under FP5, 344 research projects mobilised 461 teams from 19 Non-EU partners from the Mediterranean Basin together with their European peers. The projects addressed the key challenges in this extremely water-scarce region.
151 See INCO impact study and high impact projects analysis carried out in support of the 5 Year Assessment.
152 Women in Science and Technology in the Private Sector: A Wak-up Call from CEOs, 2003.
See http://europa.eu.int/comm/research/science-society/women/wir/pdf/ceo-position-paper_en.pdf
153 See Ricci 2004b for a review.
154 These are but some examples, but success stories are plentiful. See
http://europa.eu.int/comm/research/infocentre/export/success/index_en.html
and http://europa.eu.int/comm/research/environment/index_en.htm and http://europa.eu.int/comm/research/social-sciences/index_en.html and http://europa.eu.int/comm/research/science-society/index_en.html
155 See notably: CEC, The overall socio-economic dimension of community research in the 5th Framework Programme, 2003.
156 In 2003, the JRC provided scientific and technical support to over 80 pieces of EU legislation. More widely, it should be noted that the JRC implements its mission through Direct Actions under the nuclear and non-nuclear Framework Programmes (FP). Thematically, the focal points are spelled out in the Specific Programmes (nuclear and non-nuclear parts) and are further defined in the Multi-Annual and Annual Work Programmes. To a lesser degree the JRC also uses Indirect Actions under the FPs, additional work for customer DGs, Enlargement Actions and Third Party Work to implement its mission.
157 Among those, a few (ca. 15) relate to Written Questions from MEPs or/and to Annual Reports of JRC, while the majority point to actual policy documents (13 different policy documents often citing several research projects). For more details see Ricci Report, 2004.
158 As mentioned in the Green paper on greenhouse gas emissions trading within the EU (COM(2000) 87 final) and the proposals for the Directive by the European Commission (COM(2001) 581 final) .
159 COM (2002) 656, Community Action Plan to reduce discards of fish.
160 These results should be interpreted with care; this is an estimate based on general budget data drawn from the financial reports of the different institutions.
161 COM (2004)353 of 16 June 2004
162 http://europa.eu.int/comm/research/future/themes/index_en.html
163 Attracting the second highest level of support, after 'Human Resources'.
164 http://europa.eu.int/comm/research/future/index_en.cfm
165 See the complete set of recommendations on http://europa.eu.int/comm/research/eurab/index_en.html
166 For the Locatelli report see:
http://www2.europarl.eu.int/omk/sipade2?LEVEL=2&PROG=REPORT&L=EN&SORT_ORDER=D&S_REF_A=%&LEG_ID=6&AUTHOR_ID=28976&NAV=S"
167 A good example of that generic (horizontal) approach is provided by Israel (see Manuel Trajtenberg, R&D Policy in Israel: An Overview and Reassessment). Another interesting overview of different approaches to S&T policy intervention is presented in Larédo, Philippe & Mustar, Philippe (eds), "Research and Innovation Policies in the New Global Economy. An international Comparative Analysis", Cheltenham : Edward Elgar, 2001.
168 A detailed list of S&T priorities of the Member States, USA, Japan, Canada and Korea can be obtained on request.
169 Report of the High Level Expert Group on maximising the wider benefits of competitive basic research funding at European level.
170 Kristian R. Miltersen and Eduardo S. Schwartz, R&D Investments with competitive interactions, January 2004.
171 For actions comparable to collaborative research at national level in non-EU countries see, for instance, the linkage projects programme in Australia (Contribution from the EU Delegation in Australia to the preparation of the FP7 extended impact assessment); see also the Networks of Centres of Excellence programme in Canada: "unique partnerships among universities, industry, government and not-for-profit institutions; they are multi-disciplinary and multi-sectoral; effectively 'institutes without walls' addressing in coherent and coordinated manner strategic research issues deemed vital to Canadian social and economic development" (Contribution from the EU Delegation in Canada to the preparation of the FP7 Extended impact assessment).
172 Health and Life Sciences in Europe. A Research Strategy for the Coming Decade. The Position Paper of the Helmholtz Association for the 7th EU Research Framework Programme.
173 COM(2002) 27, Life sciences and biotechnology – A Strategy for Europe.
174 "Japan lagging in scientific research – Experts say innovation and competitiveness hang in the balance", In: The Japan Times, 2 February 2005.
175 "Life Sciences and Biotechnology : a strategy for Europe – Second Progress Report and Future Orientations" COM(2004) 250. "Biotechnology for Clean Industrial Products and Processes : Towards industrial sustainability", 1999, OECD, Paris. "The Application of Biotechnology to Industrial Sustainability", 2001, OECD, Paris.
176 COM(2002) 27, Life sciences and biotechnology – A Strategy for Europe.
177 "Report from the Commission to the Spring European Council. Delivering Lisbon. Reforms for an Enlarged Union." COM(2004) 29.
178 "Facing the Challenge. The Lisbon strategy for growth and employment", report from the High Level Group chaired by Wim Kok, November 2004.

179 DG INFSO, p. 2 of DG INFSO Coordination Group Working Paper.
180 “Challenges for the European Information Society beyond 2005”, COM(2004) 757
181 “The EU Economy : 2003 Review”, COM(2003) 729
182 Van der Wiel H. and van Leeuwen G. (2004), ICT and Productivity, Fostering Productivity, Elsevier.
183 Van der Wiel H. and van Leeuwen G. (2004), ICT and Productivity, Fostering Productivity, Elsevier.
184 Van der Wiel H. and van Leeuwen G. (2004), ICT and Productivity, Fostering Productivity, Elsevier.
185 Van der Wiel H. and van Leeuwen G. (2004), ICT and Productivity, Fostering Productivity, Elsevier.
186 “A Sustainable e-Europe: Can ICT Create Economic, Social and Environmental Value?”, Final Report on a Consultation Process on Enterprise-Relevant Aspects of the Relationship Between the eEurope Programme and Sustainable Development, Prepared by SustainIT for EC, DG ENTR, July 2003.
187 White Paper - European Transport Policy for 2010: time to decide, EC, 2001
188 COM(2004) 590; Security Research: The Next Steps.
189 Research for a Secure Europe, Report of the Group of Personalities in the field of Security Research, 2004.
190 Research for a Secure Europe, Report of the Group of Personalities in the field of Security Research, 2004.
191 COM(2004) 72
192 COM(2004) 590
193 COM(2004) 72
194 Research for a Secure Europe, Report of the Group of Personalities in the field of Security Research, 2004.
195 Euroconsult, 2002 in: White Paper, Space: A new European frontier for an expanding Union. An action plan for implementing the European Space Policy, 2003.
196 COM(2004) 65 final
197 Euroconsult 2002 in: White Paper, Space: A new European frontier for an expanding Union. An action plan for implementing the European Space Policy, 2003.
198 White Paper, Space: A new European frontier for an expanding Union. An action plan for implementing the European Space Policy, 2003.
199 For actions comparable to technology platforms at national level in non-EU countries see, for instance, the Cooperative Research Centres (CRCs) and the CSIRO National Flagship Programme in Australia (Contribution from the EU Delegation in Australia to the preparation of the FP7 extended impact assessment); see also Korea, where in order to develop core technology platforms that may drive growth in the future, the government selected 10 industries and 80 key technologies connected to these industries (Contribution from the EU Delegation in Korea to the preparation of the FP7 extended impact assessment).
200 For actions comparable to research infrastructures at national level in non-EU countries see, for instance, the Advanced Networks; Australian institute of Nuclear Science & Engineering; Equipment Grants; Institutional Grant Scheme; Research Infrastructure Block Grants Programme; Linkage Infrastructure, Equipment and Facilities; Systemic Infrastructure Initiative; and Major National Research Facilities programmes in Australia (Contribution from the EU Delegation in Australia to the preparation of the FP7 extended impact assessment); see also the Canada Foundation for Innovation programme, created in 1997 to fund research infrastructure in Canadian universities, research hospitals and non-profit research institutions (Contribution from the EU Delegation in Canada to the preparation of the FP7 extended impact assessment).
201 OJEU C 324 of 31.12.2004
202 NEMESIS was undertaken within the Environment and Sustainable Development Programme (project EVG1-CT1999-0014)
203 The US EPA has shown that by better understanding and predicting our Earth system the US could have more accurate weather forecast that would save at least $1 billion annually in electricity, would reduce damages caused by coastal storms that presently account for 71% of disaster losses, i.e. $7 billion, and would reduce aviation delays – two third of which are caused by weather conditions, avoiding $1.7 billion annually.
204 A sustainable E-Europe: Can ICT Create Economic, Social and Environmental Value ?; Final Report on a Consultation Process on Enterprise-Relevant Aspects of the Relationship between eEurope Programme and Sustainable Development, Prepared by SustainIT for the EC, DG ENTR, 2003.
205 Such criticisms have been received from participants in research projects, representatives of the Programme Committees established to supervise the Specific Programmes, specialised interest groups and in reports on implementation of the Framework Programmes commissioned by the European Commission, such as the Five-year assessments, the Annual monitoring reports, and the special report on the new instruments introduced in FP6 (Marimon report).
206 The panel was set up in October 2003 and culminated in the ‘Marimon report’ provided to the Commisison on 1 July 2004. The response of the Commission was adopted on 27.08.04 in decision COM(2004) 574.
207 Communication from the Commission responding to the Marimon report (COM(2004) 574). Attached to that Communication is a Commission services working document which contains the detailed observations from the Commission (SEC(2004)1057).
208 Andersen study quoted in Technopolis’ “Comparative Study on Administrative Burdens and Rules of Procedure between the EU Research Programmes and those of the Individual Member States”, November 1998, p.24.
209 Communication from the Commission, Evaluation Standards and Good Practice, C(2002)5267 23.12.2002. It is estimated that current total cost of Community research evaluation is around €7 million per year, or around 0,15% of the FP6 budget.
210 Such as the Continuous and Systematic Monitoring in the EUREKA programme or the systematic reporting at 2, 4 and 6 years after the funding ends, as used by the Advanced Technology Program in the US.