The Role of Community Research Policy in the Knowledge-Based Economy

Report of an Expert Group to the European Commission[1]

(November 1st, 2009)

[1] This is the final draft of the Expert Group Report on *The Role of Community Research Policy in the Knowledge-Based Economy*. It consists of two Parts: Part I Policy Report and Part II Background Report. We are particularly grateful for helpful comments from Commission services. Assistance from Hugo Hollanders and Lina Sonne (UNU-MERIT) with respect to data and editing is also greatly appreciated. The views and opinions expressed here are those of the Expert Group only.

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Executive Summary

Asked to reflect on the role of Community research policy in the development of the knowledge-based economy, the Expert Group (EG) took stock of ongoing reflections and analyses of research and innovation systems in Europe in the context of global trends, and experience gained of addressing the Lisbon strategy, including issues of governance. Active at a time of the most severe global economic and financial crisis in decades, when furthermore major societal challenges such as the long-term implications of climate change have taken on growing importance, the EG also chose to focus on opportunities for more radical reforms in Community as well as Member States' (MS) research and innovation policies.

The opportunities explored involve capitalising upon performance-related developments in research and innovation, for example created by their increasing globalisation; the tendency for research and innovation activities to concentrate in particular locations; and the rise of open innovation and the interconnectedness of research and innovation activities around the world. They are also linked to what could be called policy-driven developments, including the evident need to align research activities more closely with the resolution of major societal challenges such as climate change, sustainable development, energy shortages; to ensure that the fruits of such research achieve lasting benefits for society as a whole; the need to reduce the fragmentation that exists between both policy making structures and research and innovation actors across the EU; and the drive to improve the delivery of policy itself via administrative streamlining and improved governance.

These developments and the challenges they pose constituted the structuring device for this report of the EG. The Background Report in Part II describes in detail the main developments, challenges and policy responses that became the focus of discussions in the EG over the last ten months. The Policy Report in Part I summarises along a similar structure the policy conclusions and recommendations that the EG wishes to make. The group chose to put forward a limited number of highly focused recommendations even if its analysis covers a much wider range of issues and considerations. The group hopes that these will be useful for future reflections and policy formulations.

1. Responding to Globalisation

The globalisation of research activities is still a relatively recent phenomenon that will continue to dominate the research and innovation landscape over the decades to come. It involves not only the entrance of new actors such as China and India and a possible relocation of footloose R&D capacity, but also the agglomeration of research and innovation activities at specific locational nodes. These globalization and agglomeration trends represent a real challenge for policies primarily designed within a national or European context.

In addressing this challenge, the first recommendation of the EG is to call for a renewed public commitment to knowledge investments in the difficult fiscal years to come. It proposes a new 3% EU knowledge investment target, one that has a number of clear policy advantages over the previous Barcelona 3% target.

Recommendation 1

> ***Set a new EU 3% knowledge investment target.***
>
> *Obtain Member States' commitment to increase their investments in knowledge and set national targets so as to achieve that by 2020 1% of Europe's GDP is spent from public funds on research and development and 2% of Europe's GDP on higher education. Implementation of national targets will be under the full control of governments and will not depend on private sector investment decisions.*

A strong case can be made that the extent of private sector investment in R&D and innovation activities relates to a region's attractiveness for such investment, and this is linked directly to expected rates of return and cost of capital. The financial crisis makes the fragmentation of national markets for products and services an even bigger impediment to any increase in private investment into R&D, while regulatory differences in Europe further increase the uncertainty on the expected rate of return on such investments. It leads the EG to a second recommendation.

Recommendation 2

> ***Reduce investment risk.***
>
> *Lower the uncertainty surrounding expected rates of return on private R&D investments by improving coordination between the policy domains responsible for nurturing research, stimulating innovation and regulating market development.*

European research policies will also have to increasingly recognize the need to network, interact, and participate in the global research area. More explicit European policy responses are needed to forge links with other global centres of activity in order to create synergies and access complementary expertise.

Recommendation 3

> ***Open up ERA.***
>
> *Make Europe more attractive to all researchers and innovative entrepreneurs by taking steps to integrate those who are based outside Europe. Participate more extensively in the global circulation of knowledge.*

2. Tackling Societal Challenges

Currently the world faces a series of major societal challenges that call for urgent solutions. These include climate change, energy shortages, sustainable development, affordable high-quality healthcare and many others that cannot be solved in a reasonable time and/or with acceptable social conditions without a strong and, in the European case, coordinated input requiring technological and non-technological innovation, and (though not necessarily always) advances in scientific understanding. The central issue for the EG has been whether resources, not just research but also procurement and other investment and deployment resources, can be better allocated among European stakeholders to achieve more productive "societal use" i.e. to influence not only the rate but also the *direction* of technical change and innovation. The EG believes this to be the case.

Recommendation 4

> ***Focus policies on the direction as well as the rate of technical change.***
>
> *Channel EU and national research funds towards the resolution of major societal challenges.*

Societal challenges of the form discussed here represent systemic challenges, which few – if any – countries have either the experience or resources, or indeed the possibility, to tackle successfully on their own. In Europe in particular, the current compartmentalisation of research resources hampers the development of the critical mass of effort needed. In the final analysis, orienting EU policies towards the resolution of societal problems holds the promise not only of successfully confronting these challenges but also of nurturing the development of the ERA and creating a new growth engine for economic development. However, the EG believes that this can only happen when there is full international cooperation and a clear understanding of European strengths and ambitions.

Recommendation 5

> ***Improve international cooperation**,*
>
> *particularly for challenges of a global nature; build this cooperation on a clearer assessment of European strengths and ambitions.*

Societal challenges also raise *grand* policy challenges, such as how to achieve compatibility between these top-down initiatives and a more market-driven resource allocation logic that would allow for multiple decentralized experiments. A first basic principle is relatively straightforward: it is crucial to be non-neutral in identifying the broad agenda while being neutral vis-à-vis specific applications and approaches. Other principles, e.g. for mitigating the potential distortions created by demand-side measures designed to stimulate innovation towards societal challenges or for managing the overall progress of these complex initiatives involving many stakeholders, are far less straightforward. The EG proposes a staged approach.

Recommendation 6

> ***Create a stronger coordination***
>
> *between all relevant policies in order to better align innovative activities with the needs of society. This should involve stronger coordination between R&D support and Lead Market instruments (such as regulation, standards and public procurement) and the use of staged approaches linking support for developing innovative solutions with their subsequent uptake in public procurement.*

3. Excellence in Public Research

An obvious, yet until recently little exploited, advantage of the EU is the potential for achieving a much larger and more competitive, transparent and accountable allocation process of public resources to so-called frontier research. Such merit-based competition at the EU level is likely to create strong pressures that can drive improvements in the overall quality of public research activities in Europe.

Recommendation 7

> ***Introduce merit-based competition at EU level***
>
> *in support of individual institutions and in ways that enable stronger differentiation among universities and RTO's. Greater autonomy and accountability are also needed to support increased diversity.*

Furthermore, in addition to pleas to MS to improve the governance and differentiation of universities, the EG makes a special plea to take all steps necessary to ensure that the new European institutions created in recent years can flourish and grow on their own merits.

Recommendation 8

> ***Build truly European institutions.***
>
> *Strengthen and expand the remit of the ERC; and the Knowledge and Innovation Communities of the EIT; continue the Europeanization of research infrastructures including the exploitation of new legal frameworks for their establishment; and launch a new Joint Research Initiative scheme.*

4. Responding to Open Innovation

One important function of the ERA is to underpin Europe's capacity to take advantage of the available knowledge base through its industry and businesses. Complementing the arguments presented above, the emphasis here is on furthering the construction of the ERA as an integral part of an effective innovation *ecosystem*, which builds upon on excellence and merit-based competition. The focus here should be on what drives business R&D, how contemporary innovation processes operate, and where opportunities exist for the EU to gain comparative advantage. The development of global innovation networks and their potential impact on local innovation performance suggest that EU policies should facilitate the diffusion and adoption of practices that prove effective in this context, which (currently) are those termed open innovation practices.

Open innovation creates new opportunities for young innovative SMEs. Due to their flexibility and ability to operate in new areas of business that are uncertain but potentialy highly promising, such firms are important for pursuing radical innovations and constitute an important avenue of specialization and knowledge growth in Europe. The enhanced cross-fertilisation that is taking place among firms of different ages and sizes further enhances this capacity and helps channel innovation and knowledge flows to the benefit of the entire ecosystem. Unfortunately, the prevailing institutional conditions in partly fragmented European markets still raise formidable barriers which have limited the overall success of this process. The EG therefore recommends an EU-wide scheme that can strengthen links between high performers in research, innovation and entrepreneurship, and promote the evolution of EU specialization and the growth of young innovative firms.

Recommendation 9

> ***Support young innovative companies beyond their start-up phase.***
>
> *Launch an EU-wide 'excellence through competition' scheme encouraging young innovative companies to undertake high-risk projects and pursue radical innovations.*

Companies' practices stress the importance of market demand in the organisation of innovation processes and in the choice of location for R&D activities. In EU countries, these factors will depend partly on development perspectives of new markets. Cluster development also emphasizes the effects of agglomeration and local interactions between innovation actors. Those clusters that stimulate local cooperation can efficiently support incremental innovation, which typically represents a very significant share of the innovation activity. Those that promote research excellence and international visibility need to be connected to relevant EU and global networks.

Recommendation 10

> ***Focus support to collaborative research.***
>
> *Use selection criteria that emphasise research excellence, the potential for radical innovation and the capacity to operate globally.*

While open innovation practices raise the need for more interconnectedness, they also imply complementarity among actors and open innovation (soft) infrastructures. The challenge is to put in place the appropriate incentives and research structures to enable exploitation of such complementarities. At the European level, one such structure could be the community patent. Researchers' mobility (public-private, international) and its preconditions are another.

Recommendation 11

> ***Facilitate open innovation.***
>
> *Move quickly to the full implementation of a Community patent system and increase efforts to reduce the barriers to researcher mobility and reduce transaction costs in knowledge and technology exchanges.*

5. Adjusting for Regional Differences

Developments such as globalisation, the relocation of R&D activities and the tendency for R&D and innovation actors to concentrate in specific locational clusters can all have highly variegated implications for different regions. So too can 'spatially-blind' policy-driven developments such as attempts to stimulate excellence irrespective of locational considerations, which can act to reward existing centres of excellence preferentially and appear to conflict with aspects of regional cohesion policy. The discussions of the Expert Group focused on policy thrusts such as 'smart specialisation' that should allow regions to identify niche development strategies that allow them to satisfy local needs and grow rather than fall behind during the evolution of knowledge-based societies.

Recommendation 12

> ***Encourage the design of smart specialisation policy mixes***
>
> *capable of nurturing and exploiting the capabilities of entrepreneurial entities within regions.*

The EU's cohesion policies should incorporate this perspective, themselves be smart and use conditionality as powerful support to policy learning. Cohesion policies have an essential role to play in assisting regions to select the most appropriate smart specialisation patterns on which regional development will have to thrive. Doing so will shift the emphasis in regional policies away from the principle of subsidiarity in favour of the principle of *shared responsibility*. It thus will help to build up understanding of causal relations that can be replicated and take into account differences in context.

Recommendation 13

> ***Allocate a greater proportion of structural funds to the development of research and innovation capacity.***
>
> *In particular, make the provision of structural funds conditional upon the development of smart specialisation strategies.*

6. Improving Governance and Policy Delivery

Although the EG focused primarily on the nature and orientation of the policies needed to deal with trends and developments affecting research and innovation communities, it also discussed ways in which the Commission could improve its own governance structures, processes and policy delivery. In the view of the EG, there is a demonstrable need for the Financial Regulation to be revised so as to take into account the fact that research and innovation are inherently risky activities, in the sense that outcomes cannot, by definition, be guaranteed. Progress in this regard is of particular importance since it conditions the efficiency of the funding system at European level. For the EG, if this is not addressed as an issue of absolute priority, the present crisis shock might ultimately well go the other way: questioning increasingly the value added of Community research and leading to a future in which individual MS' efforts concentrate on improving attractiveness within their own borders and fail to achieve an effective ERA.

Recommendation 14

> ***Revise the Financial Regulation***
>
> *in 2010 by making specific provisions for research that take into account the specificities and the risks associated with it.*

As fiscal pressures mount in each MS, the effectiveness and efficiency of the many national (and regional) research funding agencies and institutions is likely to become increasingly scrutinized. And similarly at the Community level, the new European instruments and tools will have to demonstrate not just their particular strategic advantage in terms of addressing common European goals but also the administrative and governance advantages obtained through a more effective pooling of resources. In short, might the future, post-crisis MS landscape of fiscal austerity actually offer new opportunities for a more truly European based "*common"* research policy? As analysed and argued here, we believe it will. Community research and innovation policy is indeed at a crossroad. Time for a new era for the ERA.

Part I
Policy Report

Research and Innovation Policy in Europe: A New Era for the ERA

Prologue

This Expert Group (EG), set up by the European Commission (EC) at the end of 2008, was asked to review and interpret the evidence on the state of the knowledge-based economy in Europe; assess the effectiveness of existing research policy instruments and come up with recommendations on how to frame and articulate Community research policy in the post-2010 period. The Terms of Reference (ToR) referred to the need for an economic assessment, hence the dominance in this EG of experts from academic, business and policy making communities with a strong economic background[2].

A strategic mandate: 2010 as a milestone year for Community research policy

The EG was established with a clear ***strategic mandate***: to assess at the end of the mandate of the first Barroso Commission the scope of research policy in the post-2010 Lisbon agenda[3] and to discuss what the future role of Community research policy should be in relation to national, Member States (MS) research policy. In short, to revisit the so-called **"rationale/ added-value/ intervention logic"** premises of EU research policy as it has gradually emerged and taken form through a multitude of tools and instruments, and in particular the establishment of the European Research Area (ERA) in 2000. Furthermore, the EG was challenged within the limited time of its existence – January till October 2009 – to come up with practical, as well as quickly implementable policy recommendations which would take into account the complexity and full range of current Community and MS' research policies.

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[2] At the same time particular care was taken to include in the EG experts which were actively involved in existing European institutions such as the European Research Council (Mathias Dewatripont and Helga Nowotny, vice president), the Commissioner's group of economic advisors, the so-called K4G (Knowledge for growth) group (Dominique Foray, vice chairman and Georg Licht), the European Institute on Innovation and Technology (João Caraça, member of the board of the EIT), the European Research Area Board (Jan van den Biesen) and European research associations such as the European Industrial Research Management Association (Andrew Dearing, secretary general of EIRMA) and Euroscience (Enric Banda, president). At the same time, the views and opinions expressed in this Report are those of the experts and do not necessarily correspond to the views and opinions of those respective institutions with which experts are affiliated.

[3] As the ToR document specified: "in 2010, 3 years after the relaunch of the ERA project with the Green Paper in 2007 and 2 years after the launch of the five ERA policy initiatives and of the Ljubljana process in 2008,... the Commission will report on the situation of ERA. Further, in the same year the Commission shall carry out, with the assistance of external experts, an evidence-based interim evaluation of both the EC and the Euratom Seventh Framework Programmes (FP) and their specific programmes building upon the ex-post evaluation of the EC and the Euratom Sixth Framework Programmes. 2010 will thus be a milestone year for Community research policy. Moreover, as the debate on the future of the Community Budget ("Budget review") will start to impinge upon the preparation of the next EU financial perspectives and of the 8th Framework Programme, both to be implemented from 2014 onwards, a space will be open for a serious re-examination of the way the Community research budget is/should be used."

The crisis as breeding ground for new ideas

But of course the ToR could not foresee the way the global financial crisis would affect the world, and the European economy in particular, in the fall of 2008, nor the impact the crisis would have on European research, let alone on Community research policy. By historical accident, the EG met and carried out most of its analysis over the period during which the financial and economic crisis hit Europe hardest. To carry out its "evidence-based" assessment and evaluate the effectiveness of the main research policy instruments within this context appeared no easy undertaking for the EG. However, at the same time periods of crisis are also ideal moments for more profound reflections on existing policy tools and instruments. A crisis provides a good breeding ground for new ideas.

An opportunity for designing the contours of a European common research policy?

The implications of the crisis for the intervention logic, the *rationale* for Community research policy, or for the balance in Community research policy between competition and coordination in allocating resources, points to new, challenging questions. Given the fragmented responses to the financial crisis by and large dominated by MS' own interests, how can Community research policy play an effective catalyst role with respect to MS's national research policies? Might some of the new instruments such as the ERC and the EIT, introduced as new Community research policy tools well before the crisis, take on a different meaning and role over the years to come, providing the EU with direct instruments to restructure in a much more effective way the fragmented European research landscape? As fiscal pressures mount in each MS, the effectiveness and efficiency of the many national (and regional) research funding agencies and institutions is also likely to be increasingly scrutinized. And similarly at the Community level, the new European instruments and tools will have to demonstrate not just their particular strategic advantage in terms of addressing common European goals but also the administrative and governance advantages obtained through a more effective pooling of resources. In short, might the future, post-crisis MS landscape of fiscal austerity actually offer new opportunities for a more truly European based "*common"* research policy?

The global sustainability challenge

Despite its unexpected, sudden impact, particularly in Europe, the financial crisis was in many ways also illustrative of the underlying unsustainable nature of world growth over the last decade. Viewed in retrospect, that growth, at the highest level ever in the history of human kind, was unsustainable not just in terms of the global financial imbalances it created, but also in terms of the underlying technological knowledge base it relied upon. As the "World in 2025" foresight project illustrated, while world population would increase by 2025 with some 23% to some 8 billion people and world production with some 98% – resulting in a dramatic improvement in the average income per capita at the global level (Fontagné, 2009) – such growth path would, given current technologies, by and large be unsustainable in terms of increased green-house gas (GHG) emissions, long term availability of natural resources, access to water, available world food production[4].

At the same time, the economic crisis itself has tended to undermine the momentum that had developed particularly in Europe to address as an absolute priority issues such as climate change[5]. As David et al. (2009) recently argued: "The biggest threat of the process of global warming is

[4] See also Soete (2009).

[5] See in particular the EU Member Countries' endorsement in December 2008 of the package of EC Directives designed to activate its "20-20-20" renewable energy strategy – a 20% reduction of green-house gas (GHG) emissions by 2020, and 20% of energy consumption from renewable sources.

precisely the lack of long term policy commitment to minimize the likelihood that delays in checking the growth of GHG concentration levels could allow the warming process to run irreversibly out of control".

European research and innovation policy at a crossroad

There is little doubt that the urgent need to address global challenges such as climate change calls for a radical restructuring of a wide spectrum of MS policies. While the focus of the EG is on research and innovation policies, it is clear, as we discuss at greater length in Chapter 2, that many other policy areas (energy policy and procurement, public transport, environmental regulation, etc.) will also have to be involved. With respect to research and innovation, it is clear that addressing such societal challenges will require large, broad and diversified research and innovation efforts. A good example is the European Strategic Energy Technology Plan (SET-Plan)[6]: a large, broad and diversified plan of action aimed at mobilizing national and European research and innovation efforts. Diversity in research and innovation is particularly important here from the perspective of avoiding committing resources too early in the face of ongoing knowledge creation, as well as from the perspective of reducing the risk of betting on the wrong technology horse. While Europe could be said to have a natural advantage in diversity, translating it into a competitive advantage will require major transformations in the way research and innovation is organized, funded and managed in Europe. In this sense research and innovation policy in Europe is truly at a crossroad.

Structure of the Report

The EG started its reflections from a series of brainstorming discussions on the major challenges the European Union would be likely to face over the next ten to fifteen years[7], taking into account both the immediate, short term and the likely longer term impact of the crisis. These challenges represent on the one hand *external* developments such as the trend towards globalization and spatial agglomeration of research and innovation, and on the other hand *internal* responses at different levels – at the level of society, at the level of research and knowledge institutions, at the level of firms, at the level of regions. They formed the main thread of the EG's Background Report, presented below in Part II. They have also been at the centre of discussions within the EG and with representatives of the Commission.

The EG chose to put forward only a limited number of highly focused recommendations even if its analysis covers a much wider range of issues and considerations. The group hopes that these will be useful for future reflections and policy formulations, relevant to Member States as well as at the Community level. In line with the remit of the EG, which was to help frame and articulate Community research policy in the post-2010 period, these policy recommendations can be used as guiding principles for the formulation of future research policy in Europe[8].

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[6] The Strategic Energy Technology Plan (SET Plan, COM (2007) 723, 22 November 2007, see http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm) sets the agenda for an EU energy technology policy, which should enhance the coordination of national and European research and innovation efforts to position the EU in the forefront of the low-carbon technologies market.

[7] Within this framework see also the EU project "Europe 2025" many insights of which were picked up by the Swedish presidency (see the so-called Lund declaration).

[8] The EG is aware that in some cases it was much easier to define what is the priority for policy action (for example recommendations 2 and 12) rather than 'how' specific policy action should be designed. In such cases there is obvious need for further policy analysis, expert work and research.

Challenge 1: Globalization and agglomeration of research and innovation: emerging tensions

The first challenge the EG believes has affected European research substantially over the last decade, and is likely to affect it even more over the next ten years, is the trend towards globalization and spatial agglomeration of research. Globalization includes the entry of new players in new countries in knowledge production as well as an increase in the circulation of knowledge and the mobility of skilled people at the international level among existing and new players. In this sense globalization refers to the increasing multiplicity of global linkages and interconnections between companies, research organisations, universities and countries, which make up the present globalized R&D system. This definition fits well with the idea of global networks of open innovation, discussed below as the fourth Challenge[9].

At the same time, there is evidence of a persistence of an uneven spatial distribution of research and innovative activities, where research investments are often concentrated in a relatively small number of locations. The globalization of R&D, combined with the phenomenon of open innovation, has undoubtedly led to a reduction in the concentration of R&D and innovative capabilities *amongst countries* at the world level. New Asian players such as China and India have entered the global research world. However, the trend towards the physical and spatial agglomeration of research activities within countries has remained a characteristic feature of research. This holds even for new areas such as green technologies. Within Europe such geographical agglomeration challenges local development policies, and even more so European cohesion policies, an issue discussed as the fifth Challenge[10].

These globalization and agglomeration trends represent a real challenge for public policies, exacerbating some of the classical tensions and trade-offs that policymakers have traditionally been able to manage. To summarize some of these tensions:

(a) Research and innovation policies are still developed within a national context, and in the case of the EU, a European context, while knowledge and investment flows are driven by firms' and individuals' motives which increasingly take place at a global level. By 2025, the EU will represent just over 6.5% of world population; 30% of world production will be produced in Asia, compared to 20% in Europe; and Asia will also have become the first world exporter[11].

(b) In so far as Lisbon was rooted in the idea that the EU's productivity problems were of an internal structural nature[12], such European competitiveness vision has become increasingly challenged by the way ICT, as a general purpose technology (GPT), has broken down nationally and internationally the distinctions between high and low tech sectors[13]. The new challenge is how to deal with the increasing fragmentation of value chains and the increasing heterogeneity of required knowledge inputs. This requires stronger cooperation in R&D with third countries and a stronger focus on the deployment of ICT based technologies.

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[9] See also Chapter 4 in the Background Report.
[10] Described in detail in Chapter 5 in the Background Report.
[11] See Fontagné, L. (2009).
[12] In short: the EU was lagging behind in R&D because of the failure to strongly develop high-tech sectors and knowledge-intensive services.
[13] See Snower, D.J., AJG Brown, and C. Merkel (2009).

(c) Within Europe the drive towards excellence in research undoubtedly benefits from Europe's regional cultural diversity and autonomy. Excellence assessments often demand that no consideration is given to the country or region of origin of the researcher. However, for countries and regions that are in need of qualified human capital for their own catching up effort and which are in no position to match the working conditions and real income levels of richer countries or regions, this might represent a major problem.

(d) The financial and economic crisis is likely to further exacerbate some of the structural problems the globalisation and spatial agglomeration of research raise with respect to Europe. Compared to other regions in the world, the remaining fragmentation of European national markets e.g., in high-tech services, is likely to increase the uncertainty of the expected rate of return to R&D investments in Europe, and might well represent today an impediment to an increase of private investment in R&D in Europe.

Because of these growing tensions, it is important that European research and innovation policies, and Community policies in particular, fully take on board the implications of globalization and spatial agglomeration, and develop institutional solutions addressing some of those tensions. Chapter 1 of the EG's Background Report spells out the evidence for some of these trends, reviews the challenges and suggests a few solutions.

A renewed commitment from all Member States to knowledge investment

The first recommendation of the EG addresses these growing tensions. It calls for a renewed commitment to knowledge investments from Member States in the difficult fiscal years to come. Not just in basic or business R&D but in all components of knowledge investments including higher education and lifelong learning, and the deployment of ICT-based innovations and applications in services[14].

While public commitment and financial efforts can indeed be translated into clear targets, such as the 2010 Barcelona 1% public R&D funding target or the 2% higher education target[15], business investment should rather be considered as the result of such efforts: ultimately the reflection of the success of a persistent public effort that makes the country or region attractive (and visible) to private knowledge investment.

In short, the EG proposes a new 3% EU knowledge investment target that has a number of clear policy advantages over the previous Barcelona 3% target.

First, it focuses directly on what governments and policy makers are directly responsible for. Clearly the EU 3% Barcelona target has had a significant impact on MS' research and innovation policies. Over the years, a growing number of policies were introduced aimed at increasing private R&D spending and at promoting public-private R&D partnerships and technology transfer. But ultimately the influence of such policies on Europe's business R&D deficit is only indirect. As an input target, it has therefore major drawbacks. By contrast the proposed new 3% knowledge investment target is directly under the control of governments, whether in terms of funding or setting funding rules such as in the case of tuition fees with respect to higher education. This is a target for which governments and policy makers in MS can hence be held both responsible and accountable for.

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[14] While US and European firms are more or less similar in R&D intensity "within sectors", they are not similar in the service sector. In services European firms appear particularly R&D adverse. See in more detail Chapter 1.

[15] In the latter case based on public or private contributions.

Second, and as illustrated in Figure 1. 9 in Chapter 1, none of the EU MS is near, or likely to come near, this target in the years to come. In political terms the target thus offers credibility. All countries are being challenged to either find own public resources to increase such knowledge investments, alternatively to call upon private resources to invest in individual's future human capital. By leaving the latter to the individual choices of MS, the target provides also sufficiently political freedom to MS to decide how they intend to try to achieve the target by 2020.

Recommendation 1

> ***Set a new EU 3% knowledge investment target*.**
>
> *Obtain Member States' commitment to increase their investments in knowledge and set national targets so as to achieve that by 2020 1% of EU's GDP is spent from public funds on research and development and 2% of EU's GDP on higher education. Implementation of national targets will be under the full control of governments and will not depend on private sector investment decisions.*

Private research and Europe's fragmented markets

At the same time, there remains a significant deficit in private research funding in Europe compared to the US and the rest of the developed world, and today even compared to China. As argued in Chapter 1, the European business R&D deficit should be viewed as an outcome: a reflection of Europe's attractiveness to private research investment. Europe's apparent limited attractiveness reflects not only the existence of other global opportunities; it also reflects a poor capacity to support the growth of significant new businesses. Compared to other regions in the world, the remaining fragmentation of European national markets e.g., in high-tech services, is likely to increase the uncertainty of the expected rate of return to R&D investments and represents an impediment to an increase in Europe of private investment into R&D.

In short, increasing private research in Europe will depend on better coordination between research and innovation policies and competition and other internal market policies. The institutional separation at the level of the European commission between research and innovation and between research and progress on the internal market particularly in services made the Lisbon strategy less credible for the private sector. As argued above, the financial crisis makes the fragmentation of national markets for final products and in particular for services, an even bigger impediment to any increase in private investment into R&D, regulatory differences in Europe increasing the uncertainty on the expected rate of return on such investments. It leads the EG to a second recommendation:

Recommendation 2

> ***Reduce investment risk*.**
>
> *Lower the uncertainty surrounding expected rates of return on private R&D investments by improving coordination between the policy domains responsible for nurturing research, stimulating innovation and regulating market development.*

Opening up the European Research Area

From a historical point of view the globalization of research activities is still a recent phenomenon that will continue to dominate the research landscape in the years to come. It involves not only the entrance of strong new actors (e.g. China and India) and the consequences posed by the relocation of footloose R&D capacity, but also the continued concentration of research activities at specific locational nodes within an expanding global framework for research activities. European research policies will have to increasingly recognize the need to network, interact, and participate in this global research area. More explicit European policy responses are needed to forge links with other global centres of activity in order to create synergies and access complementary expertise.

Recommendation 3

> ***Open up the European Research Area***
>
> *Make Europe more attractive to all researchers and innovative entrepreneurs by taking steps to integrate those who are based outside Europe. Participate more extensively in the global circulation of knowledge.*

Challenge 2: Addressing Societal Challenges

The second challenge the EG considered in more detail was the notion of Societal Challenges (often referred to as "*Grand*" Challenges in European documents). The notion of Societal Challenges, applies to major societal problems that cannot be solved in a reasonable time and/or with acceptable social conditions, without a large scale and, in the European case, coordinated input requiring both technological and non-technological innovation, and at times, though not necessarily always, advances in scientific understanding. These include climate change, energy shortages, sustainable development, affordable high-quality healthcare and many others. In a way the central issue here is at the opposite end of the spectrum of the previous one. Can resources, not just research but also procurement and other investment and deployment resources, be shifted across European stakeholders to more productive "societal use" i.e. to influence not only the rate but also the *direction* of technical change and innovation?

Societal Challenges do raise "grand" policy challenges

For one, a Societal Challenge dimension adds a new objective to public policy whereby research and innovation are seen not as ends in themselves but as a means to a wider goal, defined as a societal benefit. In other words, in contrast to existing policies, this approach implies a focus which is neither horizontal nor sectoral, but defined by the societal challenge, i.e. involving a mix of different sectors, markets and other actors that can bring about the changes needed to achieve the challenge. Relevant actors include public service delivery organisations, private companies from various sectors, as well as various (semi-) public institutions involved in shaping the demand side and the regulatory and market frameworks that support innovation. Second, such policies aimed at influencing the *direction* of technical change will automatically imply a non-neutral allocation process with respect to the selected areas and sectors to focus on. However, departing from neutrality is dangerous since it implies guessing future technological and market developments. So the *grand* policy question, addressed in more detail in Chapter 2 of the EG's Background Report, is one of policy "programme design": i.e. how to make such large programmes, somewhat reminiscent of the old mission-oriented programmes, less vulnerable to government failures linked to wrong choices and winner-picking.

The scope, scale and immediacy of many of the most pressing societal challenges will demand the rapid mobilisation of considerable human and financial resources across many fields in order to confront them and resolve the problems they pose to mankind. There is also little doubt that science and technology, research and innovation, can contribute greatly not only to the mitigation of existing problems but also to their prevention in the future. Research is needed, for example, to understand the nature of the problems facing us; to begin to develop the tools and techniques needed to mitigate their impacts; and to underpin the subsequent development and widespread deployment and diffusion of the innovative technologies and approaches needed to prevent their reoccurrence.

Recommendation 4

> ***Focus policies on the direction as well as the rate of technical change.***
>
> *Channel EU and national research funds towards the resolution of major societal challenges.*

Europe's call

This is the strongest argument for investing in the research needed to confront societal challenges, but there are others that complement the primary argument and make the case for greater investment in research and innovation irresistible. The first of these concerns the size of the latent demand for innovative goods and services that offer the hope of new solutions in fields as diverse as health, energy and environment. If this demand can be successfully stimulated, the potential returns on investment in research – both commercial and societal – are likely to be huge as the resolution of societal challenges provides a new dynamic for innovation and becomes a new motor for economic growth and prosperity in a classic win-win situation.

A second supportive argument of particular relevance in an EU context stems from the fact that successfully confronting major societal challenges will require the mobilisation of research and innovation-related resources and the stimulation of demand along an extremely broad geo-political and institutional front. These are systemic challenges and few countries in the world, if any, have either the experience or resources to successfully tackle any of the major challenges confronting society on their own. In Europe in particular, the current compartmentalisation of research resources hampers the development of the critical mass of effort needed to tackle these problems.

In the final analysis, orienting EU policies towards the resolution of societal problems holds the promise not only of successfully confronting these challenges but also of nurturing the development of the ERA and creating a new growth engine for economic development – an especially timely prospect in the context of the current recession.

Recommendation 5

> ***Improve international cooperation**,*
> *particularly for challenges of a global nature; build this cooperation on a clearer assessment of European strengths and ambitions.*

Combining top-down and market-driven initiatives

The case for mobilising research in the fight against societal challenges may be strong, but how can it best be done? The dilemma for policymakers is that it requires policies on the supply side affecting not only the amount of research that is being conducted but also dictating or influencing the direction or orientation of the research itself; plus policies on the demand side stimulating the formation and rapid growth of new markets and the widespread diffusion of innovative products, processes and services within them; plus a degree of coordination between diverse governance systems that is on a scale unparalleled in the field of European research and innovation policy. In the Appendix to Chapter 2 in the Background Report, we propose one possible approach to some of the governance and managements issues that result from this complexity.

The recommendations of the EG deal therefore with the question of how to achieve compatibility between these "grand" societal top-down initiatives and the more market-driven resource allocation logic that would allow for "multiple decentralized experiments". A first principle is relatively straightforward: it is crucial to be non-neutral in identifying a very broad agenda while being neutral vis-à-vis specific applications and approaches. Other principles for mitigating distortions created by the provision of subsidies to favoured industries, firms and other organized interests are less ambiguous. In practice, the EG follows the direction set out in the Lund declaration. Meeting the Societal Challenges will, by definition, require strengthening of frontier research initiated by the research community itself and the need to take a lead in the development and combination of a range of key technologies as well as the creation of favourable market conditions for their deployment through demand-side measures (regulations, standards, public procurement) in particular along the lines of lead-market initiatives such as on “green technologies”. Particular attention should here be given to measures that can enhance experimentation, increase the effectiveness of public/private research collaboration and a policy focus on knowledge sharing, adaptation and diffusion of innovations, rather than just knowledge accumulation. The launch of the first Knowledge and Innovation Communities (KIC's) by the EIT should be carefully monitored and assessed as their operation encompasses the three pillars of the knowledge triangle and the multiple interactions between these.

Recommendation 6

> ***Create a stronger coordination***
>
> *between all relevant policies in order to better align innovative activities with the needs of society. This should involve stronger coordination between R&D support and Lead Market instruments (such as regulation, standards and public procurement) and the use of staged approaches linking support for developing innovative solutions with their subsequent uptake in public procurement.*

Challenge 3: Excellence in research in Europe: towards merit-based competition

The most obvious, yet until recently least exploited, advantage of the EU is the potential for a much larger and more competitive, transparent and accountable allocation process of public resources to so-called frontier research. As we discuss in Chapter 3 of the Background Report, such merit-based competition at the EU level is likely to create strong pressures on the overall quality of research. However, at the same time, great care must be taken to ensure that such new allocation systems provide solutions to the societal problems that have been identified. For example, targeted support for institutions (rather than projects) is certainly an idea whose time may have come, though there are many potential pitfalls at a more detailed level. Thus, before setting up further new instruments or agencies the experience with those that already exist should be carefully scrutinised.

Towards a strategic reconfiguration of European vs. MS research responsibilities

A clear setting of priorities at EU level and a strategic reconfiguration of what is predominantly left to MS is urgently recommended. The 'one size fits all' has never been a valid or good principle. In order to enable universities to test and improve their governance and to foster their strategic capabilities in university management in a professional way, we recommend setting up merit-based competitive schemes at EU level for universities which can provide funding with considerable European added value for those institutions that excel on a number of clearly defined dimensions. MS may want to join forces in preparing their universities by including criteria that will enable universities to better compete at EU level, e.g. within the pluri-annual performance-based contracts now negotiated between universities and their governments or intermediate bodies. Many of the issues discussed specifically for universities are applicable to Research and Technology Organisations (RTO's) as well. While it is more straightforward to urge for reinforced public-private partnerships for RTO's, there also exist plenty of unfulfilled and potentially favourable opportunities for RTO's to collaborate more closely with universities. The concrete form under which specialisation and collaboration might be developed needs to be worked out based on an understanding of the specific strengths and opportunities that pertain to each institution[16].

Recommendation 7

> ***Introduce merit-based competition at EU level***
> *in support of individual institutions and in ways that enable stronger differentiation among universities and RTO's. Greater autonomy and accountability are also needed to support increased diversity.*

Getting incentives and the governance of universities right

Incentives should include measures to support high quality recruitment at universities and RTOs, encouraging them to introduce a more proactive, international recruitment policy. One of the keys to raising the overall quality of research at universities is the improvement of their Ph.D. training through a mechanism of competitive funding for Ph.D. programmes. It could include both individual grants for Ph.D. students and institutional funding for the best PhD programmes. It must include criteria aiming for improvement of the career prospects of the future generation of researchers in Europe as well as their working conditions. A second option is to develop specific

[16] An interesting case is provided by the Forschungszentrum Karlsruhe that recently merged with the University Karlsruhe in the wake of the German Excellence Initiative. It has now been established as the Karlsruhe Institute of Technology, KIT.

funding mechanisms for PhD programmes oriented towards market needs, and therefore knowledge production which is particularly relevant for the industry and service sectors in Europe.

With respect to the *governance of universities*, the EG is critical of the current higher education governance systems across the EU which do not sufficiently allow for specialization and diversity. While the autonomy of universities is not a panacea to overcome all problems, European universities need to evolve towards improved abilities to, and responsibility for, crafting their own quality assurance mechanisms, rather than relying on centralized and standardized governments control systems. Despite recent deregulation in several countries, legal structures and prevailing funding policies still tend to severely limit the autonomy of universities, including the selection of students, the financing of education, the usage of funds for different purposes within research and education fields, the recruitment and compensation of professors. In the 21st century, universities need to act with greater speed in transforming themselves into modern, professional organizations, based on an understanding of their core skills. Differentiation inevitably requires room for specialisation in multiple directions. Students must be able to select what suits their needs and aspirations the most and universities must be able to select the students that fit their profile. Universities also need to be able to define, and choose between various options of how to define their core business and how to develop unique combinations of higher education, research and particular relations and outputs that are of relevance to society, as laid out in the concept of the "Knowledge Triangle".

Building European knowledge institutions

The focus of the EG's policy recommendations, in addition to pleas to MS to improve the governance and differentiation of universities, is on the measures needed at EU level in order to improve the quality of research in Europe in relation to its impact (including economic and wider social impact), its awareness and measurement. The further strengthening of some of the new institutions which have been created over the last years is central here.

Recommendation 8

> ***Build truly European institutions.***
>
> *Strengthen and expand the remit of the ERC; and the Knowledge and Innovation Communities of the EIT; continue the Europeanization of research infrastructures including the exploitation of new legal frameworks for their establishment; and launch a new Joint Research Initiative scheme.*

Let us briefly specify what we mean by "*strengthen and expand*" in each of the cases we wish to emphasize here.

a) The new central role of the ERC

The generation of frontier knowledge is an indispensable precondition for the value chain and the future well-being of our societies and this has been reinforced at European level through the radical policy initiative taken by the EC in setting up the European Research Council (ERC). Its success, within a very short period of time, has been widely acknowledged, both within the scientific community, as well as by MS and the EC. In order to build upon this success and to guarantee its sustainability, the Final Report to review the ERC's structures and mechanisms "Towards a world class Frontier Research Organisation" issued on 23 July 2009 has made a number of recommendations[17].

The response of the Commission has been published on 20 October 2009. Among the immediate and short term recommended actions, the legal base will be clarified and reinforced. The Director of the ERCEA (merging the functions of the Secretary General and the Director of the EA) to be appointed will have the appropriate profile ("a distinguished scientist with robust administrative experience") and will be selected following an open call. Administrative procedures that have hampered the efficient operation of the ERC will be improved and a consolidation of all activities is promised. Among medium term actions, the Commission will use the forthcoming review of the Financial Regulation as an opportunity to assess the situation and formulate possible responses to the specific administrative and financial shortcomings concerning research, technological development and innovation in general and frontier research in particular.

The EG urges the Commission to implement these recommendations and, in particular, to guarantee the independence and efficient operation of the ERC beyond 2013 in an optimal and sustained way. To this end, the ERC has to receive a higher overall budget and should become an operationally integrated, autonomous European institution sui generis, making it a truly world class frontier research funding organisation.

b) The Europeanization of research infrastructures

Research Infrastructures (RI) attract peer review selected researchers with world-level outreach by virtue of their scientific, technical, educational and managerial excellence, and are a backbone of the research system: they do not necessarily need to be "large" but they must be able to offer an excellent research service. While Community policy on research infrastructures aims to an improved coordination leading to possible integration, so far the EU contribution to national research infrastructure resources has been limited to contributing a few percent of the cost of opening up access to all researchers. ESFRI is a purely advisory body set up at the request of the Council bringing together the representatives of research ministers and a representative of the Commission; it has a mixed intergovernmental / Community approach to develop and support a coherent and strategy–led approach to policy making on research infrastructures in Europe and to facilitate multilateral initiatives leading to better use and development of research infrastructures, and on whose advice the Commission and Member States may act. The development by ESFRI of a European Roadmap for RI has induced several countries to develop coherent national roadmaps mutually connected through the ESFRI roadmap, thus producing a growing trend towards integration and upgrade of national resources, including existing potentially relevant infrastructures. Stimulated also by Community actions, the development of multi-site RI as required in several science fields (e.g. environment, biomedicine, etc.) is, in turn, helping to evolve all countries to converge in the choice of the siting also of larger, single RI, while developing longer-term joint resources.

Recently, moreover, a political agreement has been reached in the Council on setting up a specific legislation at Community level (ERIC)[18] that would allow greater institutional integration of national resources, as well as some exemptions already available for international research organisations. This is a very welcome initiative since a mechanism to deal with European research infrastructures is definitely needed. Again, lessons learnt should be used in designing a truly European approach that goes beyond the predominant national approach and develop an

[17] See http://erc.europa.eu/PDF/final_report_230709.pdf

[18] Council Regulation n° 723/2009 on the Community legal framework for a European Research Infrastructure (ERIC).

institutional integration of the national and EU support of the relevant RI on a merit-based selection at EU level.

The initiative on research infrastructures is a positive recent development of EU research policy although the decision making process is still far from efficient. In order to be able to attract the best researchers, research infrastructures must be international and develop both the highest scientific-technological competence and adequate management capabilities in a competitive environment. Supporting transnational infrastructures and granting international access to national facilities is important. It should be reinforced, and attracting the best researchers to and from infrastructures on a competitive basis should become a key indicator.

c) Joint Research Initiatives, EIT.

Another expert group, the “Expert Group on the Future of Networks of Excellence” has recommended that the Networks of Excellence scheme should be discontinued. The group proposed a revised concept of “Joint Research Initiatives” (JRIs) oriented towards long-term academic research of ‘slim-lined’ alliances between universities and research organisations. The objective of JRIs should be the creation of ‘virtual institutes’ of a manageable size of 3 to 7 partners. These virtual institutes would be committed to joint long-term research planning and activities, with a typical duration of 7-9 years. The EG welcomes this proposal which it sees as complementary to the new instruments set up over the last years such as the industry-led Joint Technology Initiatives (JTIs) and the ‘individual excellence’ supported by the ERC. It is also complementary to the EIT mission of creating so-called KICs in particular priority areas to engage in world-leading innovations producing highly qualified people with the right entrepreneurial and proactive skills and values.

For the EG, the difficulty to coordinate national policies and undertake joint actions is a major weakness in EU research policy. The JRI scheme should therefore be implemented in a ‘bottom-up’ competitive mode and committed first and foremost to enhancing ‘institutional excellence’. In addition, not all research institutions are large and have physical embodiment. Increasingly, scientific communities build up forms of coordination that concern sharing equipment, pooling datasets, setting up a shared research vision, establishing experimental protocols, validating laboratory procedures and developing Standard Operational Protocols (SOPs). These activities do not directly produce scientific output, but produce *intermediate collective research goods*, i.e. goods that are used by other researchers to improve research productivity. In most cases these goods are intangible.

The importance of research technologies, i.e. research instrumentation and new methods that have been invented or set up for purposes of research, mostly in the lab, that carry an inherent potential for wider use outside the lab, is not sufficiently recognized. In order to realize their cross-cutting, integrative potential, either for other research fields or, perhaps even more importantly, for industry/services in innovative ways, flexible opportunities need to be created that allow industry, academia and RTO’s to jointly explore, at an early stage, how basic research, applied research and innovation as well as entrepreneurial activities in general might be transformed into ‘experimental innovation’. This includes the search for new forms of practice, e.g. how to use, adapt and transform research technologies for purposes and objectives outside the laboratory. Research technologies come with the skills and knowledge of those who have been trained to use them, hence the importance of well-trained graduates. It leads us quite naturally to the next major challenge of particular relevance to Community research policy in the Knowledge Based Economy.

Challenge 4: Global networks and open innovation

As we discuss in more detail in Chapter 4 in the Background Report, innovation processes involve today a wide range of actors: firms including start-ups, universities, RTO's, private or public in nature, as well as other parts of civil society such as customers and opinion formers. Open innovation marks a departure from previous mainstream approaches to innovation. Although the basic objective ("take advantage of resources other than your own") is not new, approaches to this objective have changed considerably and have become more diverse, thereby shifting the balance from in-house activities towards the use of external resources in response to the growing complexity at the intersection of products and services as well as to increased competition. Moreover, open innovation networks tend to have a global reach, especially when firms have radical innovation strategies.

The relevance of the open innovation paradigm for the Knowledge Based Economy derives from a widespread belief that openness accelerates and broadens innovation processes by offering firms the potential to access a much broader variety of knowledge and ideas than could be generated by its in-house R&D capabilities alone. It can therefore substantially reduce the cost of innovation, whilst accelerating the process. It can also enable companies with mature markets and technologies to successfully introduce more radical technological and organisational innovations. As a result, the contribution of the different actors tends to benefit from complementary contributions whereby interactions between actors become crucial. In particular, high tech start ups, despite being small and few, can (to the extent that the local environment permits) play a fundamental role in technology transfer, market pioneering and growth. Similarly, technology transfer and public-private partnerships, while representing only a small share of R&D budgets, can constitute a major stimulus for radical innovation.

From the construction of the ERA towards a focus on Europe's innovation performance

This leads the EG to a first reflection on the future of the ERA. Complementing the arguments presented above, the emphasis is on furthering the construction of ERA as an effective innovation ecosystem, based on research excellence and merit-based competition. The focus here is on what ultimately drives business R&D, how contemporary innovation processes operate and where the opportunities for the EU to gain comparative advantage are. The development of open innovation networks is from this perspective also a reflection on the significant changes taking place as a result of globalization, as reviewed above under Challenge 1 and analyzed in Chapter 1 of the Background Report.

A number of challenges are visible through the lens of open innovation:

1. Open innovation practices requires variety in terms of small entrepreneurial activities and their avenues for growth, combined with the structures and activities of more established firms. The challenge is to put in place structures, networks and markets capable of supporting the development of such entrepreneurial activities.
2. The need for more interconnectedness of actors, activities and knowledge implies corresponding complementarity among actors and open innovation infrastructures. The challenge is to put in place the appropriate incentives and (soft) infrastructures to enable the exploitation of complementarities and reduce transaction costs.
3. As firms develop global innovation networks, a primary challenge is to stimulate demand and develop local environments that are attractive to the players that perform innovation activities and deliver commensurate benefits to the community. Local environments may be attractive in various scientific and technological areas for re-localization of R&D and innovation activities.

The good news is that considerable impact may be achieved by focusing on a few key areas. These include improving the possibility for actors to collaborate according to the different logic of their situations; improving the attractiveness of local environments within the EU in support of innovation-oriented goals; addressing the excellence of public research infrastructures and the international perspective of its institutions (as discussed in Chapter 3); identifying the EU's strategic priorities for R&D and other aspects of innovation in the face of international competition; and improving the connection between R&D and innovation policies and other public policy priorities.

Open innovation practices within an ERA ecosystem

The development of global innovation networks and their potential impact on local innovation performance suggest that EU policies should facilitate the diffusion and adoption of open innovation practices within the ERA ecosystem, without de-emphasising the importance of the specialised skills of individual actors and public authorities' overall responsibilities. ERA's current, and new, instruments can be examined in this perspective, taking into account the need for simplicity and risk-tolerance. Logically, an overall examination of ERA instruments is required including the alignment of instruments with policy objectives, and the possibility to manage the instruments effectively, including, where appropriate, across policy boundaries.

The open innovation paradigm has many policy implications for European research, such as for the Cooperation programme within the Framework Programme. They complement many of the recommendations made above. Thus, the new perspective will not just lead to a greater role for the ERC based on truly competitive criteria (see Recommendation 7), it will also require policies promoting young innovating companies and their growth at the EU level; new reflections on the role of the EIT alongside the JTIs, new forms of integrating the lead market initiative, the Eureka programme, etc. Most of all, however, it points to the importance of effective policy integration beyond R&D.

EU policies should be designed to have a direct impact on research and innovation performance, as opposed to the construction of ERA per se. Currently, most ERA initiatives are institutional in nature, and seem to take for granted that their successful implementation will eventually support the development of the knowledge economy in Europe. A new perspective requires that policy makers fully understand what drives business R&D, how contemporary innovation processes operate, and where there is opportunity for the EU to gain a comparative advantage.

This change in focus has many implications, for example for the Co-operation programme within the Framework Programme. In particular, the EG stress the importance of revamping the Framework programme to become attuned to the particular challenges a more open innovation paradigm requires.

Debates on the stagnation of R&D intensity in Europe suggest that R&D spending depends primarily on the sectors in which Europe's mature firms operate. But open innovation can, and does, challenge established companies' routines and thereby stimulate more radical developments which can permit entry into new markets. There are many recent examples of radical and high-performing innovations on the market that have come from successful start-ups and also of the enhanced cross-fertilisation that is taking place among firms of different ages and sizes. Yet many European countries have experienced limited growth of such start-ups, preventing these firms from taking a key role as an efficient channel for innovation and knowledge flows to the benefit of the entire eco-system. Since innovative start-ups can, despite their limited size and number, be a source of new activities, they constitute an important avenue for the evolution of specialisation and knowledge growth in Europe. The EG therefore recommends to promote the evolution of EU specialisation through the growth of young innovative firms.

Recommendation 9

> ***Support young innovative companies beyond their start-up phase.***
> *Launch an EU-wide 'excellence through competition' schemes encouraging young innovative companies to undertake high-risk projects and pursue radical innovations.*

The challenge is to put in place structures, networks and markets capable of supporting the development of such entrepreneurial activities. This will depend on local initiatives such as improved knowledge and technology transfer, but there are also broader issues, including the promotion of demand for innovation, the relationships between large and small companies, standard IPR issues, including the community patent and a European court linked with the European Patent Litigation Agreement (EPLA). It is likely that such actions will not be the primary responsibilities of research ministries and DG Research, but their active support will be needed for such initiatives to be well-targeted and successful.

SME-related policies in Europe have not been as successful as was hoped, for example when measured in terms of these firms' survival and growth compared to other parts of the world (Guellec and Sachwald, 2008). The difficulties faced by young innovative companies are largely due to characteristics of national economies, nevertheless the Co-operation programme within the FP has not assisted in supporting these, but was instead targeted towards achieving a particular level of participation by SMEs. The specific new EU instrument recommended by the EG could be designed so as to support the growth of innovative start ups and their evolution, in order to help overcome what Chapter 4 of the Background Report refers to as the EU's "growth paradox".

But the take-up of these developments depends also on having successful new and innovative firms, for which access to markets is vital and to a large extent comes from trading with other (larger) companies. A more integrated ERA and common EU market would contribute to a more dynamic growth of new firms within their global networks as well as the continued success at global level of established players. Lead markets are one example of instruments that could be at the intersection of ERA and the Single market. A specific instrument to stimulate demand for innovation is Pre-Commercial Procurement of R&D services, a very promising scheme that was modelled upon successful US examples and put forward by the Commission at the end of 2007[19].

Companies' practices stress the importance of market demand in the organisation of innovation processes as well as in the choice of location for R&D activities. In EU countries, companies' R&D activities will partly depend on the development perspectives of new markets, for example to face the challenges of ageing and environment: such markets must provide the prospect of sustainable profitability. Cluster development also emphasizes the effects of agglomeration and local interactions between innovation actors. Those clusters that stimulate local cooperation can efficiently support incremental innovation, which typically represents a very significant share of the innovation activity. Those that promote research excellence and international visibility need to be connected to relevant EU and global networks. The Knowledge and Innovation Communities (KIC) of the EIT could play a role in this context.

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[19] See http://cordis.europa.eu/fp7/ict/pcp/home_en.html and Chapter 2 on societal challenges.

Recommendation 10

> ***Focus support to collaborative research.***
>
> *Use selection criteria that emphasise research excellence, the potential for radical innovation and the capacity to operate globally.*

Open innovation practices raise the need for more interconnectedness of actors, activities and knowledge implying complementarity among actors and open innovation (soft) *infra*structures. The challenge is to put in place the appropriate incentives and research structures to enable the exploitation of complementarities. At the European level, one such *infra*structure could be the community patent, which should be complemented with EPLA. The full implementation of the community patent would be an important step to promote efficient open innovation practices but also to support the development of innovative young companies in the EU. Researchers' mobility (public-private, international) is another such *infra*structure. The European Institute of Innovation and Technology (EIT) and its Knowledge and Innovation Communities provides a specific example of such mobility measures. A third *infra*structure could be supported by focusing on stimulating the development of knowledge exchanges. In this perspective, public policies should ensure transparency in the development of innovation intermediaries and markets for knowledge. These infrastructures would enable enhanced connectivity between small and large firms and between young and more established companies in international and open innovation networks.

Recommendation 11

> ***Facilitate open innovation.***
>
> *Move quickly to the full implementation of a Community patent system and increase efforts to reduce the barriers to researcher mobility and reduce transaction costs in knowledge and technology exchanges.*

Challenge 5: Towards a spatially blind, yet cohesive ERA?

A central question of the analysis of the EG set out in Chapter 5 of the Background Report is whether a spatially-blind ERA can still be a "cohesive" ERA. Positive local effects of the ERA are indeed not always guaranteed: there are likely to be strong interdependencies between places resulting in positive or negative direct and indirect effects – precisely the interdependencies which can lead to the spatial agglomeration discussed in Chapter 1. Ignoring these local effects can lead to a number of unintended negative consequences, including *local irrelevance*: investment may be favoured in activities which are inappropriate and not in line with the actual or potential comparative advantage of regions/places. The trade off between excellence and cohesion is context specific and can only be addressed by taking local relevance into account.

As analysed in Chapter 5, a number of concepts have been introduced or rediscovered in the policy debate at the European level, which appear particularly relevant in order to design a better policy trade-off. They are place-based policies, smart specialization and conditionality.

Combining merit-based and place-based policies

The recent debate on European cohesion policies[20] sees the main purpose of such policies less in terms of redistribution than in terms of triggering institutional change and breaking up inefficiencies and social exclusion traps through the provision of public goods and services. This triggering of institutional change can come about only through an exogenous public intervention which can improve things by upsetting the existing balance. However, for this intervention to be ultimately effective, it will need to be accompanied by increased local involvement and sufficient local involvement can only be achieved through locally relevant activities.

There is of course a large literature on policies aimed at technology catching up particularly with respect to emerging and developing countries[21]. That literature has emphasized the particular role of "new industrial policy" in fostering restructuring and technological dynamism, going beyond the traditional focus on background conditions and improvements in the investment climate. From an innovation perspective, it is important to understand the policy implications of the 'binding constraints' view of economic growth[22]. Thus policy should indeed rely on 'islands of excellence' that exist in (almost) every country to reform less successful areas. Yet unlike the old 'picking winners' industrial policy model, the key assumption is now that no one, government included, can have a panoramic view of the economy – all views are necessarily partial. Mechanisms for creating new opportunities are likely to be search networks – private-public partnerships and programmes that could bring together the better performing segments of the public sector and the better performing segments of the private sector in an attempt to relax and unblock binding constraints. The focus of policy is thus on missing connections, which, when established, should have synergistic and increasing effects.[23]

This new perspective recognizes that growth constraints are never general or generic, but are most often specific. It resonates well with the Barca Report (2009) which argues that the *'design of*

[20] Following the publication of the influential Barca Report (2009).

[21] See e.g. World Bank report (2005).

[22] The 'binding constraints' view of growth is an idea of Rodrik's which was fully taken on board in the World Bank (2005) study. This is a targeted approach which requires an in-depth understanding of country specificities, rather than the application of best practice solutions.

[23] In that respect, the New Industrial Policy is quite similar to the so-called second generation innovation policies (see EU, 2002).

integrated interventions must be tailored to places, since it largely depends on the knowledge and preferences of people living in it' (p. 6). For example, and as argued in the case of the New Member States, ways of increasing the industrial relevance of their science base by linking centres of excellence in science to areas of industrial strength will have to be found. In addition, policies will need to differentiate between research and non-research based activities as the latter are particularly relevant to catching up countries and regions. In general, there is little implementation of policies that differentiate in any operational way between non-research-based activities that lead to innovation, and research based activities – in particular R&D – that do lead to innovation. In particular, the evaluation criteria for the use of the EU structural funds are fitted to traditional industry and infrastructures (roads, railways etc.) and – in practice at least - strongly impede the use of these funds for research activities and infrastructure.

A further integration of regional R&D into EU R&D networks is likely to lead to an improved R&D system in terms of quality and international excellence, but not necessarily in terms of local relevance. In fact, the gap between supply and demand in terms of local R&D may even widen. However, one can expect that over time, as cohesion regions' R&D systems become integrated into the ERA, this will have positive effects in terms of dynamism and excellence in R&D, with countries and regions' R&D and innovation expertise becoming 'plugged' into EU R&D and innovation networks. There will also be positive effects on higher education systems through the reorganization of universities and increased R&D levels which in turn should lead to higher quality teaching. To achieve this, policies are needed that extend beyond ERA and stretch into development, engineering and knowledge intensive services as these are particularly important for innovation in cohesion regions.

Designing smart specialization policies

Most European regions still appear characterized in their research and technology specialisation by imitation and regional subsidy (European or national) competition. This has led to the new concept of designing *smart specialisation*[24] policies. The argument goes as follows. So-called General Purpose Technologies or Tools (GPTs) have properties which appear to define a particular useful framework to clarify the logic of *smart specialisation* for both regions that are at the technological frontier and those that are less advanced. While the leader regions will invest in the invention of a GPT (biotechnology, information technology) or the combination of different GPTs (bioinformatics), followers might then invest more in the "co-invention of applications", that is the development of the applications of a GPT in one or several important domains of the regional economy. Doing so, these regions will likely enter into a more realistic and practical competition logic by defining a competition arena composed of a much smaller number of players. In other words, while certain European regions might be well placed to play their specialisation cards in the GPT production domain, most others will be in a much better position to develop applications of these general purpose technologies in domains that are important for the region in question[25]. In short, there are strategies for everyone.

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[24] See in particular Foray, 2008; and David, Foray and Hall, 2009

[25] A general purpose technology is in fact distinguished by its characteristics of horizontal propagation throughout the economy and the complementarity between invention and application development. These complementarities are fundamental. Expressed in the words of the economist, the invention of the general technology extends the frontier of invention possibilities for the whole economy, while application development changes the production function of a particular sector. Application co-invention increases the size of the general technology market and improves the economic return on invention activities relating to it. There are therefore dynamic feedback loops in accordance with which inventions give rise to the co-invention of applications, which in their turn increase the return on subsequent inventions. When things evolve favourably, a long-term dynamic develops, consisting of large-scale investments in research and innovation whose social and private marginal rates of return attain high levels. This dynamic may be spatially distributed between regions specialised in the basic inventions and regions investing in specific application domains.

The search for such smart specialization patterns does, however, not involve a bureaucratic process (plan) or a foresight exercise. Rather it concerns an essentially entrepreneurial-driven discovery process in which the new knowledge produced relates to what appears to be the *pertinent specialisations* of the region. One might consider this as first and foremost a learning process, which is primarily the responsibility of entrepreneurs in private and public sectors (universities, RTO's, more broadly higher technical education) who are best placed to discover the right specialisations. At the same time, the *discovery* of such pertinent specialisation domains has high social value since this knowledge is going to define the direction of company investments and research organisation projects. Yet these entrepreneurial entities will only be able to capture a limited part of his investment's social value since other entrepreneurs will swiftly move into the identified domain. There is consequently a risk of not seeing enough entrepreneurs invest in this particular *smart specialisation discovery* process. Public policies will thus have an essential role to play: a more modest one than what regional policy makers often like to do by selecting themselves the right specializations, but one of encouraging entrepreneurial entities to find their own way and help them to coordinate and be connected to each other in this discovery process. One may also think of providing incentives to (encourage) entrepreneurs; identifying complementary investments (educational and training institutions for example); and the pruning of investments which turn out to be inappropriate ex post.

Recommendation 12

> ***Encourage the design of smart specialisation policy mixes***
> *capable of nurturing and exploiting the capabilities of entrepreneurial entities within regions.*

Implementing specialisation using conditionality

By itself, however, the notion of smart specialisation is of little help if it is not articulated into a clear European policy framework and implementation plan. If it were to be realized by MS, it would perhaps take a long time before a European set of regional smart specialisation patterns would emerge, but it would ultimately need little European policy input; if it is a guiding concept for European social cohesion policy, implementation becomes critical.

For the EG the appropriate policy tool to implement European smart specialisation appears to be conditionality. Conditionality has two main levels: at the macro-level and at the micro-level. At the macro-level the European Commission might apply conditionality in the planning phase and in the relations with national and regional governments over Structural Funds. The object of conditionality should be focused on specialisation. Countries and regions should give evidence of a strategic learning process in which they have the ability to assist entrepreneurs, both from the private and public sector in the identification of areas in which the goal to compete at international level is realistic and feasible, although with risks. As argued above one might also think of private-public partnerships and programmes that could bring together the better performing segments of the public sector and the better performing segments of the productive sector in an attempt to relax and unblock binding constraints. At the micro-level national and regional governments may apply extensively policy tools based on conditionality on intermediate and final results.

Promoting GPT networks is an important policy issue at the EU level. Such networks are not the ones which only involve the population of the "superstars" of a given field. These are networks between very heterogeneous agents – from the leading knowledge centres and from the more peripheral regions aiming at co-inventing applications. Many incentive and coordination problems arise in such situations, because working with “an old industry” in a remote region is not likely to hold great attractions as a career move for the scientists, engineers and business managers that are in the “lead regions”, yet access to their knowledge may be vital in the early stages of the “application enterprise.” How does one help solve this problem in a “generic” fashion that does not turn into a government subsidy for the development of a particular industry in a specific region? This is one instance of a class of difficult issues that frequently occupy the attentions of economists and experts from international organizations like the World Bank that work in developing regions. The resolution in this case lies in the idea that there are phases in smart specialization where temporary “industrial policy” measures, such as infant industry policies, are warranted.

Smart cohesion policies need however to use conditionality as a powerful support to policy learning because it helps to build up the causal relations that can be replicated, taking into account differences in context. Cohesion policies have an essential role to play in assisting regions to select the right, smart specialisation patterns on which regional development will have to thrive. Doing so will shift the emphasis in regional policies away from the principle of subsidiarity in favour of the principle of *shared responsibility*[26].

Recommendation 13

> ***Allocate a greater proportion of structural funds to the development of research and innovation capacity.*** *In particular, make the provision of structural funds conditional upon the development of smart specialisation strategies.*

[26] Slavo Radosevic, Michael White, Aleardo Furlani (2008).

Concluding reflections: crises opportunities for an augmented ERA

The global financial crisis represents in many ways a window of opportunity for more radical reflections on the relationship between Community and national research policies. The new instruments such as the ERC and the EIT introduced as new Community research policy tools well before the crisis, can take on a new meaning over the years to come in providing direct instruments to restructure the fragmented European landscape, what the EG called an *augmented* ERA. The EG's report suggests to continue in this direction and conceive this *augmented* ERA as a research and innovation ecosystem with new direct instruments and/or the refocusing of existing instruments.

As the fiscal pressures in each MS increase, the question of improving the efficiency of national research funding agencies, of higher education and public research funding are likely to be raised in many countries. It is in other words now that the various European Technology Platforms, Joint Technology Initiatives, ERA-nets, etc, just as in the case of SET plan will have to illustrate not just their particular strategic advantages in terms of common European goals but also their financing advantages through an effective pooling of resources.

But also under conditionality: one of a better governance of European agencies

But for those opportunities to be realized it will be essential that the key governance issues are not just discussed but also solved so as to allow these approaches to flourish[27]. For the EG, the opportunity for the further deployment of those new instruments, including the use of articles 169 and 171 of the Treaty, will only be successful if they illustrate their particular European valued added, also through their administrative flexibility and best practice governance. Only then will they play a central structuring role for a new, post-crisis *augmented* ERA: possibly a meaner and leaner one given the dramatic financial constraints in some countries, but more effective and truly European than ever before. This raises crucial challenges with respect to the governance of the implementation structures (as in the case of Article 169) and of Community bodies related to those instruments (as in the case of Article 171). Given the scale and complexity of the R&D and innovation-related tasks now being pursued at EU level, it is clearly desirable to move towards agency management in some situations. However, there is a real risk that this will lead to more risk intolerance, for example if agency staff find themselves facing personal liabilities for administrative errors. To avoid a further increase in FP transaction costs, "agentification" only makes sense if the new agencies will not be subject to the Financial Regulation or if the Financial Regulation is adapted to allow agency staff to adopt a more risk-tolerant and trust-based approach. The advantages of the "arms-length" approach include the obligation on the part of the Commission to be much clearer in its statements of objectives than at present.

There is within this context far too little of a learning culture in the EC. When combined with the growing and widespread trend towards risk-aversion on the part of officials (linked to personal liability in the Financial Regulation) organisational and strategic innovation tends to become stifled. Regardless of why they exist and who is responsible for them, the overly 'bureaucratic' ways of the Commission must hence be genuinely reformed and simplified, and not just 'outsourced' under the guise of Executive Agencies. For the EG it is clear that one of the main obstacles, currently determining the ways in which the Commission operates, are the financial rules imposed on the

[27] See for instance de Graca Carvalho, M & R. Marimon (2009), in the framework of the *Knowledge for Growth* expert group). This report analyses the current major trends in the governance of ERA, notably the new importance of EU stakeholders-led bodies such as JTIs, the EIT and the ERC, and the issues linked to this.

Commission. These results have introduced a management culture which is largely based on mistrust. This leads to the question of whether research should be treated differently in order to stimulate more innovation. This question can best be addressed by examining the broader objectives and the longer-term consequences of different approaches. There is in the view of the EG an evident need to account for the certain degree of risk that is inherent to research and innovation. Consequently the only way to create a break-through towards a more risk-tolerant and trust-based approach as a general and long term priority will have to be to revise the Financial Regulation, with the full backing of European Parliament and Council. For the EG though, the need for this change must also, and much more strongly than is currently the case, be argued by the Commission itself based on its clear understanding of objectives and the consequences of failing to achieve them.

A final recommendation: towards a more risk-tolerant and trust-based ERA

The EG therefore recommends that the revision of the Financial Regulation planned for 2010 should include an explicit derogation for research, whose management culture rests on trust. Progress in this regard is of great importance since it conditions the efficiency of the funding system at European level. Indeed for the EG, if not addressed as an issue of absolute priority, the crisis shock might well go the other way: questioning increasingly the valued added of Community research and enabling a future ERA based much more on MS' national efforts of attracting research talent within their own borders.

Recommendation 14

> ***Revise the Financial Regulation***
> *in 2010 by making specific provisions for research that take into account the specificities and the risks associated with it.*

Epilogue: On society's need for research

As an EG composed primarily of economists, we felt it important to emphasize at this concluding end of the Policy part and as introduction to the Background Report, to explore how the major trends and challenges that currently affect European and global research policy will also be confronted with explanatory factors that differ, sometimes radically, from those commonly used and accepted by the economics community.

Concepts and terms used

Before doing so, it might be appropriate to spend some time on concepts and terms used. Since the critical publication of Stiglitz, Sen and Fitoussi's report on the Measurement of Economic Performance and Social Progress (September 2009), it seems natural to pay also some attention to the many measurement problems involved in analysing research and innovation. As the reader will have noticed, the term "research" is usually and quite deliberately joined with "development", as in R&D, although the two activities clearly differ, with a high proportion of private investment directed more towards "D" than "R". The term "innovation" is also often joined with "research", while again there is not necessarily a connection. For the purposes of the discussions in this Policy Report as well as in the Background Report that follows it is useful to highlight that whatever terminology is employed – basic, fundamental, frontier, scientific, blue sky, curiosity-driven, etc. – all these activities aim at or involve the production of *new knowledge*: research explicitly so and development and innovation through the continuous processes of learning that drive progress down technological and other cost curves The new knowledge may concern new phenomena or entities that do not exist in nature or are an artifice or an imitation of how nature works, and of ways to make use of the phenomena and entities. New knowledge is also embodied in research tools and technologies that constitute the experimental system through which further new knowledge is produced.

A particular and inherent uncertainty in research arises from the fact that basic research itself is not goal-directed in a strict sense. The outcomes are not known in advance, since what is looked for are new properties, mechanisms and phenomena. Basic research therefore is an open and an open-ended process in which serendipity, the accidental finding of interesting and relevant phenomena that one was not looking for, is often decisive.

This inherent uncertainty is a characteristic feature that basic research activities share with the uncertainties that are inherent in the process of innovation. Certain preconditions, like adequate funding, institutional and organizational structures, scientific networks and technological configurations, scientific and entrepreneurial leadership, team size and composition, can play a crucial role. With the benefit of hindsight from contemporary and historical case studies, favourable and disadvantaging configurations can be identified, but no prescriptive guidelines can be deduced that will predict when breakthroughs will be achieved or what form these will take. Human creativity as expressed in basic, curiosity-driven research – as distinguished from applied research and development where already available knowledge is further used or developed towards specific ends – avoids such prediction and planning. It nonetheless remains dependent upon a favourable environment and other enabling conditions, among which adequate investment is a *sine qua non*. In many frontier research fields, it has become impossible to delineate what constitutes basic or curiosity-driven research and what constitutes application. In the life sciences, for instance "to know life is to (re)make life", meaning that new knowledge is gained using (novel) technologies to intervene and manipulate living organisms (Nowotny and Testa, 2009). For the biomedical field the term 'translational research' has been introduced to designate the processes through which new knowledge is brought closer to patients and their needs. Clearly, continuous feed-back and the inclusion of users and patients has become an important feature in interlinking basic research with the uses to which new knowledge is put.

Arguments and rhetoric

The political commitment in a period of financial crisis to investment in basic research has probably been recognized most explicitly by the US Obama administration, which has included a major boost for basic research in its Economic Stimulus Plan. It was preceded, among other things, by an argument put forth by 49 American Nobel-prize laureates and other distinguished American scientists: "Funding scientific research serves dual purposes: it is an immediate stimulus to the economy and an investment in US leadership in science, engineering, technology and education. This leadership is vital to the US's economy and prestige, as well as to success in such goals as achieving energy independence, mitigating global warming and treating and curing disease. In addition to the immediate multiplier effect of research spending, the intellectual property created by publicly funded research leads to the creation of innumerable small companies and, ultimately, many large companies in biotechnology, energy, computer technology and other scientific and engineering fields. Federal seed money is multiplied by inflows of private capital. Federal funds also support virtually all research training and much of the academic training of those earning their PhDs in science and engineering in US institutions and so train the personnel who staff, as well as create, US scientific and engineering companies" (Letter to Obama, 2009)[28]

These are clearly more goal-oriented arguments, evoking a 'multiplier effect', than one usually hears in the European context. Common to all arguments are two salient issues that reoccur in public discourse. First, investing in basic research is in need of political justification. Second, whatever arguments are used, they reveal – often unintentionally – the inherent tension between investing into frontier, curiosity-driven research and the desired, economically profitable outcome.

The problem of finding the right justification for public policy action has become even more crucial in recent years particularly after it became evident that the expansion of State intervention was, and is likely to continue in the future even more so, to be in contradiction with the upper limits to public expenditure (the so-called fiscal crisis of the State). Since public policy involves the allocation of scarce resources, it has become standard practice to invoke an economic justification, usually associated with theories that predict a relation between expenditure and desirable outcomes.

In the case of research and innovation, the economic rationale for public policy has traditionally been found in the economics of information and in particular the path breaking contributions from Kenneth Arrow and Richard Nelson at the end of the 50's when the "cold war" debate was at its height and the debate raged in the US about the much stronger commitment of the USSR to space research. Arrow and Nelson each on their side proved that the supply of new information by private agents would inevitably be lower than the societal optimal level. In other words, if the public sector would not fund research and/or did not protect innovation (for example, through the granting of intellectual property rights such as patents), society would suffer from a lack of investment in basic research. Historically, this rationale was often used jointly with another argument, first associated with Vannevar Bush's *"Science - The Endless Frontier"* in 1945. It stipulated that if a country invests heavily in basic research, then a steady flow of applications, inventions, products, and ultimately opportunities for growth and societal benefits would accrue to that country. Implicit in this argument was the view that uncertainty would be reduced stepwise, so that public investment in the upper stages would be of larger social value. Hence, the risk for private investors that operate downstream, closer to the market would be lower. Underlying this logic is the so-called 'linear model', stipulating a more or less straightforward progression from basic research to applications

[28] Similar arguments can be found in the new Japanese government's commitment to research.

which would eventually end up as commercially viable products on the market. This model, although still beloved by policy-makers, has come under increasing attack over the last twenty years, both by economic historians such as Nathan Rosenberg and scholars of history and social studies of science. It is considered today as being outdated, no longer capturing the complexities of research and innovation in a globalizing world.

In order to better understand current developments in science, technology and innovation as well as the vagaries of political – often rhetorical – justifications for investing into R&D and into basic research in particular, it is necessary to probe the broader societal context. Inevitably, this includes empirical evidence of what has and has not worked under given historical circumstances. But one also needs to take into account an important democratic component. Today, the role of science in society is fully accepted in modern liberal democracies. The sometimes uneasy relationship that arises around the imagined or real risks associated with scientific-technological developments is acknowledged and serious efforts are undertaken to include citizens' participation in deliberative ways. In a pluralistic society in which differences in values cannot be simply reduced to those held by a majority and where public discourse often juxtaposes 'values' to 'science', one should not forget that science itself is based on a deeply held, societal value: that of free inquiry into what is yet unknown. In this sense, science and democracy are completely aligned today. Investing into research is itself based on a profound societal value.

The place for visions

Why, we may ask, is the economic argument tilted in such a way to become a justification for public policy, if its foundations are so problematic? The first answer comes from the fact that economists are asked to produce a rationale for policy making, which intrinsically has a short term view as it is bound to the electoral cycle. It is difficult for politicians to justify to taxpayers an increase in public funding for research by invoking long term effects, particularly if these effects are uncertain. A second answer results from the fact that the benefits of nationally funded research can benefit other countries, thus creating an externality. This adds a difficulty to the political process: taxpayers may ask why they should pay when others will benefit. In this context we may recall that funding R&D within the EU still remains overwhelmingly in the responsibility of Member States, with only approximately 6% coming from the EU budget (leaving aside funding of intergovernmental programmes and institutions, like CERN, EMBO etc.).

Does this mean that the entire process of political justification is flawed? Of course not: citizens have a right – and are expected – to be involved in the crucial decisions of what their futures will look like and how science and technology can contribute to its betterment.

In our view policy makers build up a rhetorical argument for the short term, while they keep economically valid arguments for the long term. They promise short term results for an increase in funding, although they may believe it is not possible to deliver. A quick glance at the US system shows its extraordinary ability to develop strong rhetorical arguments to increase federal support for basic research. Vannevar Buch's manifesto *"Science - The Endless Frontier"* opened the way for the establishment of the National Science Foundation; President Kennedy's speech to Congress promising a man on the moon led to a large increase in mission-oriented funding; President Nixon's War on Cancer created the political support for a massive increase of funding in NIH. Interestingly, President Obama's stimulus plan promises new and better jobs in the green economy, energy and environment, by appealing to the freedom vision of the Fathers of the Nation. In all these cases the rhetorical arguments have been firmly linked to national goals to be achieved through mission-oriented action (with national security figuring as one of the primary goals). The mission-orientation is backed by the structure of the major US funding institutions, including the Department of Energy and Department of Defence.

Europe has yet to develop a strategy on the rhetorical level which is sufficiently convincing to mobilise the mass of citizens to devote large resources to a long term scientific vision that transcends electoral cycles. This, despite the fact that Europe has already been successful in developing such rhetorical strategies that have driven the provision of advanced public services such as healthcare that require a strong science base. Economic arguments alone, even if politicians become more sophisticated in their uptake and use, might not be sufficient to elicit and guarantee public support, even if the promises made will exclusively benefit citizens. In the political arena, the results promised as the outcome of investment into research will always have to compete with other, more near term promises that may be felt more urgently or have greater emotional appeal. Therefore, a convincing argument for public support of research must include a visionary narrative, with goals that can be specified and credible mechanisms in place, showing how they can be achieved.

Part II
Background Report

Introduction

Summary

This Background Report contains the detailed analysis and findings of the Expert Group on "*The Role of Community Research Policy in the Knowledge-Based Economy*". Its five core chapters explore 1) the globalization and spatial agglomeration of research and innovation; 2) research and research policy in respect of addressing societal challenges; 3) public research in Europe; 4) global networks of open innovation and the ERA; and 5) regionalisation and the future of European research policy. The analyses lead to a consistent set of policy recommendations, which are given in detail in the individual chapters and pulled together in the accompanying Part 1, the Expert Group's Policy Report.

The Expert Group's Terms of Reference

This Expert Group (EG) was set up by the European Commission (EC) at the end of 2008 to deliver a report on "*The Role of Community Research Policy in the Knowledge-Based Economy*". Its members were asked to review, assess and interpret the existing evidence on the state of the knowledge-based economy in Europe as well as the effectiveness in terms of role, objectives and rationales of the existing main research policy instruments, and to come up with recommendations on how to frame and articulate Community research policy in the post-2010 period.

The EG's Terms of Reference (ToR) explicitly referred to the need for an economic assessment coming up with new ideas, analyses and so-called "evidence-based recommendations for actions". For this reason, the group included a preponderance of experts with strong backgrounds in economics, drawn from the academic, business and policy making communities.

At the time these ToR were written, the policy context was very much dominated by what could be called the "available time-slot" for a re-examination of the intervention logic of Community research policy. The intention was to present the EG's report at the end of the mandate of the first Barroso Commission and at the start of the debate on the post-2010 Community policy agenda. At the same time, the EG would be in a position to reflect on some of the new instruments introduced in Community research policy over the last decade. One may think of the European Research Council (ERC) with its research funding allocation based purely on excellence competition, and also of other new, and at first sight successful, top-down EC initiatives such as the Strategic Energy Technology Plan (SET) aimed at the mobilization of research across the EU in some key so-called "societal challenges" areas such as (in this case) energy technology policy; or the more active, "non-financial" role the EC hopes to play as catalyst for reform at member states level with the launch of the so-called Ljubljana process. As the ToR document put it: *"How to develop a Community research policy which can have leverage effect on national research policies, programmes and systems"*.

Responding to a Changing Debate and the Global Financial Crisis

From the outset, it is important to highlight the self-imposed constraints to which the EG has adhered, brought about by the rapid changes in the context for its work. For example, the EG's terms of reference did not foresee the way the global financial and economic crisis starting in late 2008 would affect the world's and, in particular, the European economy. Consequently, they did not anticipate the need to examine the potential short and long term impact of the crisis on European research and on Community research policy.

By historical fluke, the EG met, and carried out most of its analysis, over the period when this crisis hit Europe hardest. To carry out its "evidence-based" assessment on "the state of the knowledge-based economy in Europe" and evaluate "the effectiveness of the main research policy instruments" within this rather extraordinary context appeared an extreme challenge, given the timeslot constraints imposed.

First, given the exceptional historical context, no attempt has been made to provide a systematic overview of the current state of the knowledge economy in Europe. The EG decided instead to rely on prior work and sources. Nonetheless, individual chapters do contain extensive data and evidence-based analysis where these are considered relevant to the key trends explored in this report.

There are many indicator reports available from the EC, OECD and individual Member States providing statistical information on the knowledge economy in Europe up to 2007[29]. Numerous other analytical reports, including some carried out by members of the EG for the so-called Knowledge for Growth (K4G) group[30], others for the World in 2025 foresight project coordinated by DG Research and BEPA[31], provide detailed insights on key issues such as the underlying reasons for the EU-US gap in knowledge investments and in scientific performance over the last twenty years, and assess Europe's future outlook. Only very limited indicator data were available covering the period of the financial crisis, the fall of 2008 and the first semester of 2009, so the EG considered that analysis of the state of the European knowledge economy anno 2009 would be difficult and potentially unreliable[32].

Second, periods of crisis can be ideal moments for more radical reflections on reforms of existing policy tools and instruments. A crisis provides a good breeding ground for "new ideas"; very quickly though it appears that implementation is problematic and, as the impact of the crisis appears to soften and the first signs of recovery become visible, the policy discussion shifts back to the old debates and the security of existing policy tools. This is why it was felt it would be a good idea that the present EG report would accompany the independent report "Preparing Europe for a New Renaissance" written by members of the European Research Area Board. The latter report provides an outside, particularly useful long-term and visionary framework, which this EG could also integrate in its own formulation of new ideas and policy recommendations.

Third, it appeared necessary to make a more thorough examination of the changing policy context within which the so-called "emerging debates" described in the original ToR would now take place. For example, what will be the implications of the crisis for the intervention logic of Community research policy, e.g. for the balance between competition and coordination as so-called "rationales"

[29] See also the latest EC Science, Technology and Competitiveness 2008/9 key figures report: http://ec.europa.eu/research/era/pdf/key-figures-report2008-2009_en.pdf
[30] See http://ec.europa.eu/invest-in-research/monitoring/knowledge_en.htm
[31] See http://ec.europa.eu/research/social-sciences/pdf/the-world-in-2025-report_en.pdf.
[32] For preliminary data see Archibugi, D., M. Denni and A. Filippetti, (2009) and European Commission (2009).

for Community research policy? Given the fragmented responses to the financial crisis dominated first and foremost by Members States' self-interest, how can Community research policy and the Commission play its catalyst role with respect to MS's national policies?

To achieve this, the EG started its reflections from an internal brainstorming discussion on the major challenges the European Union is likely to face over the next ten to fifteen years,[33] taking into account both the short and long term likely impact of the financial crisis. These major challenges, some representing forceful *external* developments such as the trend towards globalization of research and innovation capabilities, others representing *internal* potential responses at different levels – the broad societal level, the level of research and knowledge institutions, the level of firms and regions – have formed the *guiding thread* (le "fil conducteur") of the EG's report, and provide the basis for the analyses set out in the following five chapters.

[33] Within this framework see also the EU project "Europe 2025" many insights of which were picked up by the Swedish presidency (see the so-called Lund declaration, July 2009).

Chapter 1: Globalization and spatial agglomeration of research and innovation

1.1 Introduction: general setting of the policy challenge

Over the last decade it has become clear that research policies face a radically new landscape in which their territorial focus is being put under severe pressure. On the one hand, the dramatic decrease in the marginal cost of reproduction and diffusion of information has led to a world in which geographical borders are less and less relevant for research and innovation. Knowledge accumulation and knowledge diffusion may take place at a faster pace, involving an increasing number of new entrants and providing a threat to established institutions and positions. This is the globalization trend, which affects research and innovation in a variety of ways.

On the other hand, contrary to a possibly, somewhat simplistic reasoning, globalization does not really lead to a *flat* world: one in which differences in research and innovation capabilities across countries and regions would be constantly reduced. Quite to the contrary, one sees evidence of spatial or geographic concentration of knowledge production and innovative activities at the international level *across* countries, as well as a highly differentiated pace of growth of these activities *within* countries, i.e. across regions and territories. This is the tendency towards spatial agglomeration, which also has a strong impact on the way in which research and innovation activities are carried out.

The globalization and spatial agglomeration trends present a real challenge for public policies, exacerbating some of the classical tensions and trade-offs that policymakers have traditionally been able to manage. To summarize some of these tensions:

(e) research and innovation policies are still developed largely within a national, or in the case of the EU, a European context, while knowledge and investment flows are driven by innovative motives taking place at the global level;

(f) the globalization of knowledge increases the incentives for talented people to move internationally and while this improves career opportunities, it might at least in the short term be considered harmful for countries that are in need of qualified human capital for their own national catching up effort and cannot match working conditions and real income levels of richer countries;

(g) the drive towards excellence in research demands that ultimately no consideration is given to the country (or region) of origin of the researcher, but this creates tensions for those countries or regions with a weaker scientific and technological base, due to historical reasons and low levels of development.

Because of these tensions, it is important that European research policies, and Community policies in particular, fully take on board the implications of globalization and spatial agglomeration, and develop the institutional solutions addressing some of those tensions.

This first Chapter is devoted to spelling out the evidence for these trends, review the challenges, and suggest a few solutions. In the first two sections of the Chapter, we set out the scene both with respect to trends in the globalization of research (section 1.2) and its spatial agglomeration (section 1.3). We then draw some first conclusions from this analysis on the rationale for European integration in research and in particular on the relevance of the European Research Area concept (section 1.4). We then review the empirical evidence since Lisbon on investments in Europe both with respect to research (section 1.5) and with respect to higher education (section 1.6) and draw in a final section (section 1.7) some policy conclusions on the implications for the Lisbon agenda.

1.2 The globalization trend

Since the end of the XX century and the beginning of the new Millennium, it is probably fair to say that the largest part of world wide economic growth has been associated with an acceleration in the diffusion of technological change and world wide access to knowledge, as opposed to individual countries' domestic efforts in knowledge accumulation.

The emerging digital technologies, in particular the easy and cheap access to broadband, the world wide dissemination of Internet and of mobile communication, have been instrumental in bringing about a more rapid diffusion of best practice technologies. With the advent of digital information and communication technologies over the last two decades, the international exchange of knowledge in various forms and formats has drastically altered for example, (but not exclusively):

- the internal and external organisation of research;
- the scope of national versus international knowledge spill-over effects;
- the locational advantages of knowledge agglomeration.

It is not only the emergence of digital information and communication technologies that has shifted the balance in the direction of a more transparent, globally-level playing field, but also the development of global institutional frameworks governing the "rules of the game" of international knowledge flows (trade, investment, IPR). In particular, many capital- and organisation- embedded forms of technology transfer such as licences, foreign direct investment and other forms of formal and informal knowledge diffusion have contributed to speeding up access to critical knowledge.

A remarkable consequence of the globalization trend is the emergence and multiplication of world class knowledge centres in emerging economies. It is no longer true that emerging economies are laggard in technological development. Due to massive investment in higher education and research, favourable demographic dynamics, and outsourcing of manufacturing activities, but also increasingly of product development from rich countries, there has been the emergence of several hotspots of innovation in emerging countries. As documented in a recent *Harvard Business Review* article which interestingly calls for a complete turnaround of US manufacturing industry from the current trend towards outsourcing, a large part of high tech components of many mass consumer products are now not only manufactured but also designed in China, South Korea and India (Pisano and Shih, 2009). It is true that this global shift is mainly concerned with the D of R&D, that is, with the somewhat more routinized segments of Development which do not need to be tightly integrated or co-located with other (more fundamental) research capacities but also benefit from agglomeration effects. One can still stay that the less routinized and most science based segments of inventive activity remain extremely concentrated in USA and the other developed countries – what counts here is the proximity to leading edge academic research, the advantages of co-location with other firms and thick local markets for specialized inputs, services and human capital, so-called knowledge agglomeration externalities. So, whereas one can expect a substantial increase in Indian and Chinese research it will be many years before the share of inventive capacities changes significantly.

At the same time, emerging countries have shown a remarkable capacity in moving upstream in the value chain, from outsourcing of manufacturing activities to autonomous process technology development, then to product development, design, and applied research. For example, together with a national targeted technology policy, Eastern Asian countries have successfully and aggressively pursued the goal of a rapid increase in the scientific quality of their universities, using both monetary and non-monetary incentives as well as institutional reforms. Although data are not easily available, it is well known that many academic leaders in European universities have in the last five years been offered positions and large research budgets in fast growing universities in Eastern Asian countries.

The major questions are hence whether participation in these D-types of activities will ultimately have spill-over effects in the sense of building local capacities to expand further and more basic research, and the extent to which this will be magnified by the new approaches to innovation, which are leading to the development of global, open networks of activity (see Chapter 4). In any case, we see more countries with the potential to compete for global knowledge hubs in certain fields:

* they have pockets of academic excellence;

* they have strong educational programs;

* they can fund major programs to create research infrastructures and attract leading academic researchers;

* they have already strong entrepreneurial activities that respond to market incentives;

* they can benefit from sophisticated users.

While European research policy has been concerned for many years (and is to a large extent still today) with the issue of head-to-head competition with the United States in science and technology, it is clear that there are today a series of new entrants in the international knowledge competition, that have ambitions and resources to play a primary role in the not too distant future.

1.3 The spatial agglomeration pattern

The spatial agglomeration pattern represents the other side of the coin. While new countries enter international knowledge competition and hence reduce the dominance of established countries and the concentration *across* countries, there is at the same time a persistent pattern of agglomeration *within* countries. There is a large amount of evidence that innovative activities tend to concentrate spatially, in a few regions and cities (see for instance figure 1.1). This is true for both scientific production and technology. This agglomeration of innovative activities is mainly centred around large metropolitan areas, or city-regions, often including large capital cities. The agglomeration of innovative activities is part of a larger long term phenomenon of concentration of population in urban areas, and is one of the determinants of it (Hall, 2006). Within urban areas on a global scale, there is a strong hierarchy effect, with most innovative urban areas attracting more and more innovative investments. This is particularly true at European level.

It is important to note that globalization and spatial agglomeration are mutually compatible. While the entry of new countries following globalization clearly means a reduction in the *overall* worldwide concentration of research and innovative activities[34], still these activities agglomerate

[34] As the *Key Figures report 2008/2009* clearly notes, the share of EU-27 over global activities moved down from 2000 to 2005, from 23% to 22.5% for full time equivalent researchers, from 26.4% to 24.4% for GERD, and from 36% to 30.9% for patent applications. The corresponding figures for the US are even sharper: from 26.8% to 24%, from 38.6%

locally in a few areas within countries and regions, producing a spatial hierarchy which is persistent over time.

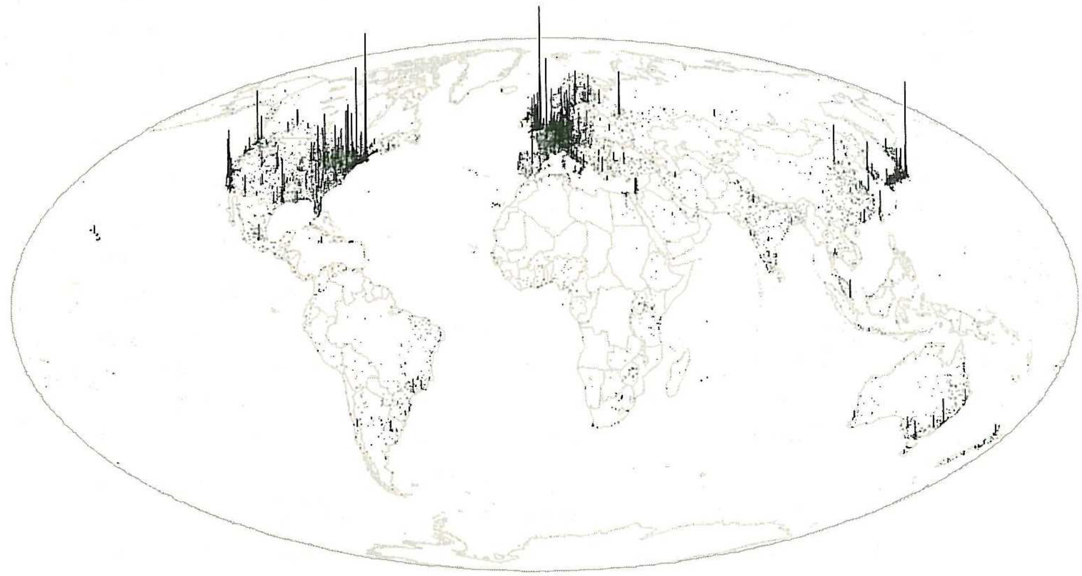


Figure 1.1: Concentration of scientific output at the global level
Source: Wagner (2008).

Spatial agglomeration depends on several factors: access to large pools of qualified human capital, proximity to research centres, urban environments, active presence of financial intermediaries, knowledge spillovers. Recent empirical analysis on the US shows that productivity is larger in large cities: "Bigger cities certainly attract more skilled workers, and there is some evidence suggesting that human capital accumulates more quickly in urban areas" (Glaeser and Resseger, 2009).

It is also recognized that the main causal relation does not flow from location to innovation, but the other way round. It is because a pool of competences is created at a local or regional level, whatever the source (large companies, high quality public research etc.), that other innovation actors decide to co-locate in the same place.

In a certain sense, agglomeration exploits *localized* dynamic economies of scale, i.e. larger dynamic efficiency is achieved if the supply of skilled factors of production at local level exceeds some threshold. Interestingly, this concept applies to both mobile and immobile production factors.

Mobile factors in the knowledge economy refer to highly skilled and talented people, who move in search of good places to work: i.e. attractive, creative, challenging locations. The attractiveness of a particular location, e.g., when it comes to attracting the best national and also foreign scientists and engineers, matters greatly for enabling local knowledge agglomeration. It is essential that qualified human resources are on the move; internationalization brings the potential for win-win through dynamic exchange processes involving movements of people between complementary locations and knowledge domains (Andersson et al, 2009), making the "brain gain" to prevail largely over "brain

to 34.6% and from 39.7% to 33.1%, respectively. The complementary increasing shares are owned by Developed Asian economies (JP+KR+SG+TW) and the Rest of the world. These trends imply a global *reduction* of concentration.

drain". This benefits larger and already integrated countries with large job markets, such as the United States, where the effect is clearly visible. In the EU, this is a much more difficult process: witness the still enormous difficulties in creating a unique job market for researchers based on the portability of welfare rights. The international mobility of human resources, therefore, leads to the agglomeration in highly attractive locations on an international basis.

There are also immobile factors, however. Despite the advance of internationalization, increased mobility will co-exist with immobility in other respects, as some factors are inherently fixed geographically. In fact, specific local assets give rise to rents which help generate precious value added and which may be the key in attracting mobile factors, or serve as "glue" retaining what would otherwise be footloose. The availability of certain skills at a particular site may, in other words, form a critical complementary resource for others. Not all knowledge exchange is codified, but there are critical tacit elements that may have to do with human understanding and trust, for which geographical proximity matters greatly. Social infrastructure, including arenas and meeting places where informal and more or less unplanned exchanges take place, may be important for what synergies will materialize between different assets.

The knowledge resources that complement each other in a particular site may reside within a certain scientific discipline or other knowledge domain, where they form a critical mass of knowledge generation. Again, however, there may also be critical interaction between different kinds of competencies. The attractiveness of research in a particular location may be boosted by unique linkages between researchers, innovators, entrepreneurs, financiers, and other actors and institutions that matter for knowledge accumulation and use. Further, what represents a critical mass of focused and/or complementary knowledge resources, is not a given.

Immobile factors contribute to spatial agglomeration of innovative activities because of path dependence at the local level. Regions and cities with a large endowment of highly skilled human resources, research centres and top quality universities, urban innovative environments and large companies, may increase their own attractiveness for mobile workers. In a certain sense, therefore, spatial agglomeration is favoured by the dynamic interplay of mobility and immobility.

So far these agglomeration dynamics hold in general but also in particular scientific or technological fields. In the former case, indicators based on publications, patents or R&D expenditure at regional level shows a clear hierarchy in innovative activity. In the latter, one might imagine that more recent fields could escape from a rapid concentration dynamics, spreading over countries and regions, at least in the infant stage. Quite to the contrary, spatial agglomeration reproduces itself even in new fields. As an example, recent worldwide data on nanoscience and nanotechnology show an impressive pattern (www.nanotrendchart.com). Almost 20% of total scientific production worldwide in 2005 took place within only 12 districts, 40% within only 35 districts and more than 70% of production in 200 districts. Among the top 12, only two are Europeans (Paris, ranked 6th with 11550 articles, Berlin, ranked 12th with 7662 articles). The leading European areas invariably include capital cities (London, Zurich, Madrid). The first non-capital areas in Europe are Louvain (23rd with 5782 articles), then Grenoble, Aachen and Delft. The four largest areas are from Asia (Tokyo, Beijing, Kyoto, Seoul). This impressive concentration took place in less than 20 years, if we date back nano S&T to the invention of the Atomic Force Microscope, or in less than 15 years, if we consider the take-off of scientific production in the early 1990s. While this might at first sight appear remarkable, because nano S&T, differently from biotech, has many scientific origins, not just one (e.g. matter physics, chemistry, electronics, biology, materials science) and could thus be expected to be based on a more diffused pattern, one might also argue that precisely because nanotechnology needs to build on so many existing strengths, it would link naturally to existing concentrations particularly when there is the local interest/will to apply these resources in the new field.

The tendency towards spatial agglomeration creates the need of pursuing measures which can help underpin the development, based on immobile factors, of unique local assets and arenas capable of attracting the most productive relevant mobile production factors. Crucial reforms may be those that strengthen research infrastructure, social infrastructure for immigrants, free up incentive structures for creative reflection and the launching and testing of new ideas. Some such measures can be instigated at European levels, others require national action, yet others have to do with what measures are taken by individual universities and other knowledge institutions, to upgrade and sharpen their specific capabilities.

In adopting such measures, the established position of a current industrial giant or leading industrial site cannot be taken for granted. History is marked by the gradual rise and often rather sudden demise of dominant economic and societal interests. A too dominant position or excessive sunk costs tends to lead to a lack of openness and increasing reliance on defensive action that will eventually hurt the strongest of firms, regions and nations. For such reasons, research policies should not give priority or privilege to established institutions, and the EU, precisely because of its traditional industrial and institutional strengths, must guard carefully against this situation. All positions needs to be constantly tested: they have to excel out of continued strong performance. Furthermore, with the information society, the advantages of flexibility and niche strategies are on the advance. There must always be the chance for newcomers to challenge the incumbents. The globalization driver continuously challenges the established agglomerations.

1.4 Challenges for current thinking on European research policies

European internal competitiveness or cooperation within global flows of knowledge?

As argued above, most of the evidence of the last ten years points to the particular importance of the international dimensions of knowledge accumulation in having brought about growth. The geographically bounded nature of the way knowledge accumulation and diffusion was thought to operate has fundamentally changed, leading to arguments on the one hand that the world is flat (the globalization trend) and on the other hand that the world consists of local knowledge peaks (the spatial agglomeration trend).

The distinction between knowledge creation and accumulation on the one hand with its accompanying policy emphasis on the need for support for (frontier) research efforts aiming at strengthening the knowledge creation capacity of countries and regions; and on the other hand the global spill-overs and diffusion of such knowledge as a result of formal and informal knowledge flows, knowledge sharing and diffusion, has always been recognized. It has sometimes been defined in terms of the difference between knowledge *stocks* and knowledge *flows*. The international balance between the two has, however, shifted over time.

What are the implications of this shift for European research policy?

It is probably fair to say that the focus of much of European (both national Members States and Community) research policy has been on strengthening the domestic, European knowledge accumulation process starting with the original Lisbon agenda, subsequently made explicit in the 3% R&D Barcelona target: raising the stock of knowledge in Europe. Europe's internal competitiveness weakness became linked to Europe's apparent technological and research weaknesses and thereby attracted the political attention of European policy makers who elevated research to one of the central foci for policy making. Surprisingly if there was one emerging trend the Lisbon strategy did not address, it was the global spreading of knowledge to new, emerging economies and the implications that this would have for Europe's future position in the emerging global knowledge economy. In this sense, Lisbon was rooted in the idea that the EU productivity problems were of a structural nature, i.e. the EU was lagging behind in e.g. R&D because of the failure in developing sunrise sectors. In essence, it is the old idea of structural change towards high-tech sectors (Soete, 2009).

However, in the new stage of globalization and deployment of ICT the link between the economic prospects of a sector and the economic prospects for local employment in that sector is also progressively breaking. As ICT has become a truly general purpose technology the distinction between high and low tech sectors breaks up, and knowledge intensity becomes embedded in all economic activities. The stock and flow distinction becomes by and large irrelevant. Thus, it becomes increasingly inappropriate to rely on education and training policies that aim to move workers from identifiable insecure jobs in declining sectors to identifiable secure jobs in expanding sectors – as suggested prominently in the Lisbon strategy – as all sectors require adaptability and knowledge upgrading (Snower, Brown and Merkel, 2009). The new challenge appears today to deal with the increasing fragmentation of value chains and the increasing heterogeneity of skills and required knowledge inputs. This requires by definition a much stronger cooperation in R&D with third countries and stronger focus on deployment of ICT based technologies.

In many emerging areas of intensive global social and societal change, including also rapidly evolving market opportunities, the central concern today is more linked to the sharing of existing knowledge, than just to the accumulation of new knowledge. One obvious example is the array of "green" technologies whereby the global climate challenge represents one of the most formidable global policy challenges for a more rapid diffusion of knowledge, knowledge absorption and the implementation of eco-innovations across the globe. Global sustainability is unlikely to emerge as a consequence of policies aimed at strengthening national (or European) research/knowledge accumulation, it will ultimately be dependent on the extent to which such knowledge concentration peaks are actively flattened out to the rest of the globe. As Paul David (2009) has argued, such policies actually require a lot of experimental applied research. To the extent that the ERA can concentrate resources more effectively, create stronger research networks, and foster mobility within the Union, it will undoubtedly reinforce the Lisbon process and enhance research concentration across the EU. But as illustrated in the case of energy research, such policies, as in the case of current FP7 energy funding, often appear devoted only to one particular technology, in this case fusion research: a technology that will not be able to help meet the European climate and energy objectives until well beyond 2050. The Commission's SET initiative is from this perspective a particularly insightful illustration of the need to broaden research and knowledge policies to include much more research experimentation as well the global societal demand side.

In short, there is a need for policies to go beyond the current ERA into an *augmented* ERA. By this we mean that the current concerns with the scale, duplication of R&D and Fifth freedom issues should be re-examined in view of the advanced production and technology integration, the global nature of R&D challenges and the urgency of global diffusion-deployment. Specifically, this would mean a stronger third country dimension in all ERA related activities.

The relevant Research Area: European or Global?

Another very important implication of the shift towards global knowledge flows regards the institutional process of construction of the European Research Area.

The notion of a European Research Area, as it took shape and became probably the most successful "add-on" to the Lisbon 2000 summit agenda, was based on the argument about *scale* as the basis of European integration. An argument which had already become gradually eroded by then, since the international knowledge diffusion and worldwide mobility of researchers had become the norm in many scientific fields in the 90's.

Also at the industrial level, as in the case of the semi-conductors industry, the sector which had been at the centre of many of the European research framework programmes, the growing competition from Asian countries such as China with even bigger scale advantages than the US, challenged also the European integration focus on scale. The semiconductors *scale* advantage which had been greatly enhanced by GSM mobile phone demand, effectively the killer applications for semiconductor producing firms in Europe, had quickly become challenged. Similarly, in the case of services, Europe appeared confronted with major difficulties in reaping *scale* gains of harmonisation and integration. The consensus agreement on a revised and limited services directive was only achieved in 2006. Actually in service sectors, most strongly characterized by *increasing returns* to network *scale* advantages, associated with the delivery of services, reaping European scale advantage always appeared difficult if not impossible in the context of 27 member countries with differences not just in regulatory regimes, but also in languages, cultures, tastes and habits.

From a broader historical perspective, there is of course little doubt that the economic integration process in Europe, as it became gradually and step-wise enlarged to include a broader set of European policies in areas such as precompetitive research, had a major effect on intra-European research cooperation and networking. Higher education and research had been left out of the European treaties and remained the prerogative of national member states' policies (Caracostas and Soete, 1998). However, with the gradual increase in size and scope of the FPs, researchers in different EU member states found themselves gradually pulled into closer European networking and cooperation. In some European countries, national funding of research was actually reduced with the amount of European funding obtained by national researchers. In a similar way to trade theories on economic integration, it could be argued that this European research integration process had strong positive but also some negative effects. The strong positive effects came in the form of new European research "creation" through the additional amount of joint EU research projects initiated and the new insights such research would provide into specifically European problems. However, there were also potentially negative effects through what could be called research "diversion", i.e. a redirection of nationally funded research activities with an international, non-European focus towards European research issues. From this perspective, the creation of the FPs and the new European inducement mechanisms towards researchers in Europe to collaborate more intensively with each other, was never considered a purely zero sum game. The diversion effects of knowledge with researchers preferring to network with other European colleagues primarily for the sake of European financial support, may lead "to a *cocooning* of knowledge inside a region's physical borders, precisely at the moment that knowledge is internationalising" (Soete 1997).

As discussed in the previous section, the FPs were designed at a time when strengthening the international competitiveness of particular European high-tech firms and sectors was considered essential for Europe's long term welfare, and they did undoubtedly help to achieve this outcome in parts. Some of the industrial firms/sectors concerned became successful at the world level, but others failed dramatically. Today most of those EU sponsored programmes benefit as much firms of European as of foreign origin, as long as they are located in Europe.

At the same time, the international accessibility to what has been called "codified knowledge" of direct relevance to most of the research communities in the world, increased dramatically through the use of new information and communication technologies (ICTs). While support for intra-European research collaboration certainly with respect to the joint use of large research facilities in areas such as "big science" and digital broadband infrastructure continued to be very much welcome, most research collaboration became in effect global in nature, going well beyond the European borders. It is what could be called (yet another) *European paradox*: as Europe invested in intra-European research, in the collaboration and exchange of scientific knowledge among European scientists, or even in the technological strengthening of the competitive potential of European firms, the advantages of such geographically "bounded" collaboration became gradually more and more marginal, given the dramatically increased opportunities for the fast exchange of information and cooperation.

The globalisation trends described above have only partially undermined the ERA oriented policy agenda. In many ways the ERA appears today still a necessary but insufficient response to the new stage of globalization. Instead of being overly focused on intra-EU issues a much broader research policy agenda is needed oriented now also more explicitly towards global research and innovation challenges. In some of those global areas the issue is first and foremost one of a more rapid diffusion of new technologies, in other areas one of a major global research mission effort, and in each case new approaches to innovation may stimulate and amplify the issue. Such challenges raise also major questions with respect to the respective roles of Community and national research policies: not so much one of the traditional ERA type dealing with the need for an internal European rebalancing of those roles, but one of a repositioning of those respective research policies vis-à-vis those global challenges. In some countries, national research policies have taken a global lead in addressing some of those issues; in other countries, research efforts have been channelled primarily through community funding.

A response to global challenges will require, as also announced by the new Obama administration[35], substantially more R&D, including mission oriented R&D. However, as discussed in more detail elsewhere in this Report, such global, new mission oriented R&D should be quite different from the conventional view of national, mission R&D. It should be *mission* oriented only in objective, and very much globally network-based in implementation. In addition, mission R&D should target technologies on a broad front. For example, and as recognized in the SET plan, energy R&D actually requires a broad portfolio of technological options. Unlike conventional mission R&D energy, such R&D is technology specific, not general purpose, and hence its potential is restricted to a narrow range of economic activities e.g. wind, solar and nuclear energy to power generation, hydrogen and biofuels to transport etc. As Bosetti (2009) has stated: "This will have to be followed by significant technology deployment costs (that) may have to be incurred before low-carbon technologies can become competitive at market prices" (Bosetti et al., 2009). This point appears even more valid when considering global deployment needs. The diversity of technology options and the need to share knowledge across the globe can be successful only if it is based on extensive networking (see also David et al., 2009).

A challenge to the rationale for European integration in research?

The process of European integration in research and innovation closely resembled with some delays though the process of economic integration of the EU. Table 1.1 below helps locate the current concerns with the ERA in a longer term perspective of EU integration.

	Stages of economic integration		**Stages of integration in RDI**
1958-1987	**Trade integration** - Customs Union integration - reduced formal barriers - an expansion of internal EU trade - barriers to the mobility of investment	1972	**Awareness of need for common R&D policies** - Benefits of CERN, EMBO recognized - Resolve to implement a common policy in support of treaty Article 2

[35] See Obama´s NSF speech, April 27th 2009.

	and labour remained		
1987-1993	**Internal market integration** - single market - removal of the remaining mobility barriers to capital and labour flows as well as various product market reforms - freedom to locate and operate in every EU country market completed by 1993 - EU firms shift towards core activities - competitive advantage is not based any more on country specific factors but on the ability to optimally spread and link activities across Member States and at the global scale	1984 - 2000	**R&D integration based on scale rationale** - EU R&D support based on the principle of subsidiarity - cooperative R&D programs
1993 >	**Global market integration** - leading EU firms have globally rationalized their activities - globalization of leading EU firms is also driven by inability to reap benefits of flexible labour and product markets	2000 >	**Towards a European Research Area** - networking of existing centres of excellence - a common approach to financing large research facilities in Europe. - greater mobility of researchers - Fifth Freedom policy agenda
2000	**Lisbon strategy**	2000	**Lisbon strategy**
2010	**Post-Lisbon strategy**	2010	**Augmented ERA agenda** - ERA in globalized R&D system - focus on cross border knowledge exchange, especially extra-EU

Table 1.1: Stages in European integration in economic, research and innovation policies
Source: Our elaboration on Bowen and Sleuwaegen (2004).

The parallel between the institutional process of integration of markets and economies on the one hand, and of integration of RDI on the other hand is illuminating. It calls into question the underlying rationales and requires a re-examination.

As Table 1.1 highlights, the trade integration stage has its parallel in the emergence of European, Community research policy, such as the introduction of the first Framework Programme (1984-1987). European research policy in this initial stage appeared to be justified by the scale or cost of cooperation rationale. The overall criteria formed the basis for the principle of subsidiarity and, at least in principle, served as the delineation between national and Community level policy (Georghiou, 2001). The basic tenet of EU RTD policy was the promotion of co-operation. This stage, which started in 1984 with the first Framework Programme, had been largely completed by the year 2000.

Stage 2 of the EU integration process was driven by the objective to establish the internal market. This stage was largely successful as it helped firms to prepare for global competition. However, there are still (too) many protective practices which hinder a full implementation of the single market. There are too many directives that have not been fully transposed into national legislation; inadequate progress has been made in securing standardisation and mutual recognition for the supply of services; there are delays in liberalizing markets particularly those in the public sector; there are the well-known difficulties that have arisen in agreeing on an efficient, workable European intellectual property rights; there are distortions caused by various forms of fiscal competition.

In parallel to this development, within research the concept of ERA was developed, the aim of which was to counteract national fragmentation and create an integrated space. ERA encompasses but also goes beyond a reform of the FP's by introducing two new large-scale instruments: Integrated Projects and Networks of Excellence. These have been designed to break with previous FP's emphasis on smaller projects and create more "European Added Value." A third, more ambitious instrument is EU participation in research cooperation sponsored jointly by two or more member states. These variable geometry programs and actions at European level have not been well advanced except through the recent introduction of different ERA-Nets. The ERA project which was initiated as early as 2000 is still far from complete. The non-existence of a truly European research area is due to the compartmentalisation of public research systems and the lack of coordination of the manner in which national and European research policies are implemented.

The philosophy of ERA greatly resembled of course the logic of the Single Market. The advantages of the Single Market were seen primarily in the advantages of a market that would become bigger than that of the USA or China. Similarly, the advantages of ERA are seen in critical mass and the opening of national programmes.

The third stage is driven by further advances of globalization which has given rise to a more complex unbundling of value chains. Increasing international flows of knowledge have become also more varied. Cross border flows include science knowledge, the licensing of know-how, the export and import of final products, the procurement of intermediate goods and services (offshoring), equity investments, and the attraction and use of immigrant experts and labour. These diverse flows have also very different degrees of transferability. Hence, a policy focus on knowledge generation and scale related issue in such knowledge generation should be seen in the context of the use of knowledge through cross border flows. In this third stage EU firms are facing serious challenges to compete in the globalized economy, outside and inside EU. The same applies to the ability of European locations to build unique local knowledge hubs and, on that basis, attract and create incentives for the most productive mobile knowledge resources. Policy issues that arise are no longer mostly related to the issue of EU integration but of global integration and the role of the EU in a much larger and globally changing space.

Although R&D is the least internationalized business function of most firms, the process of the internationalisation of R&D has further advanced, and is likely to further advance with the economic crisis. As we discuss at greater length in Chapter 4, with a few notable exceptions, traditionally R&D was internationalised mainly to adapt products and processes to local conditions. However, this is now changing through the upgrading, specialization and fragmentation of dispersed R&D units. In addition to adaptation-driven R&D, the globalized R&D activities now include emerging economies, especially China and India. The drivers of the internationalization of R&D are changing.

Above, it was argued that with the third stage of globalisation and open flows of knowledge, *scale*, at least in its static meaning associated to economies of scale, should be reconsidered. Scale is important for R&D and innovation, but its impact applies very differently at various levels. It is important to note that, if the notions of scale, critical mass and integration are used in an undifferentiated, poorly articulated, non evidence-based way in designing RDI policies, they may be harmful. In fact, it must be recalled that the existence of increasing returns is always an empirical matter, not a general law, nor a general statistical regularity. One should always use empirical data to deduce whether increasing returns are at stake, and how large their effect is. This means that there might be a mismatch between the level at which increasing returns apply and the current policy focus. As an example, many European governments have initiated policies for merging institutes of Public Research Organizations (PROs) and for merging universities. In both cases the rationale has been scale and critical mass. But the empirical evidence suggests that economies of scale apply at the level of research teams and laboratories, where there is a relatively small minimum efficient scale effect but also potential flexibility benefits to be achieved when it is possible to juxtapose different research capabilities, while it is more controversial when applied at the level of institutes and universities, where there is risk of losing sight of these team benefits.

At the same time, we know that increasing returns are at play in the case of the job market for researchers, in the size of funding for research projects in technologies subject to indivisibilities, or for the issue of pre-standardization/standardization/size in final markets for innovative products. In all these three cases size may be absolutely crucial. Still, policies to build up an integrated job markets for researchers across European countries lag behind. Instead of pursuing national policies for merging institutes or universities, governments should actively pursue the creation of a pan-European job market for research, one in which the mobility of researchers is fully implemented.

Luckily, policies for increasing the average size of funding, reduce duplication, and coordinate research agendas across countries started under the Open Method of Coordination, using art. 169 of the Treaty, and ERA-Net schemes, and Technological Platforms, are all positively addressing the issue of scale. On a similar positive vein, the Lead Market Initiative started to address the issue of the size of final markets as a powerful incentive to industrial R&D. It is therefore important that the rationale for integration is made explicit and articulated in a full scale theoretical framework.

There is no place where the lack of a theoretical foundation for policy making has become so clear than the recent EU policy on Networks of Excellence. Starting with FP 6th, this new instrument was explicitly launched with an aim of "durable integration" of research activities at European level. Again, the arguments underlying this policy goal were crafted in the language of overcoming fragmentation and reaching critical mass in the international competition. No serious reflection was given, however, to the meaning of integration across various scientific disciplines, different degrees of maturity and institutionalization of underlying scientific fields, plural research paradigms, and stages of the research-innovation continuum when applicable. Integration has a totally different meaning in genomics, nuclear safety, immigration studies, or in political economy. Given this ambiguity in overall policy goals, actors involved in Networks of Excellence defined themselves a plausible ad hoc definition of integration and tried to pursue it (Luukkonen and Nedeva, 2009). The result was that, although Networks of Excellence have probably delivered an interesting and valuable array of results, their success in terms of durable integration has been varied and somewhat elusive[36]. If integration is to be pursued, a more articulated and theoretically informed design of instruments has to be put in place.

On the other hand, it is well known that the advantages of scale may be out-weighted by benefits of flexibility and adaptiveness, as sometimes there is a trade-off here both for an economy and an organisation. Unfortunately, how these important factors weigh together is by and large ignored at the level of policy making. Hence, what we may expect is double process of completion of the ERA agenda, still pursuing the overall goal of integration, but also its modification through what we already referred to above as an *augmented* ERA agenda.

1.5 The European "business R&D deficit" and related policies since 2000

[36] See the Expert Group on the *Future of Networks of Excellence*. Final Report. DG Research, September 2008.

It is important to discuss the implications of the above changes on the investment into R&D at the level of European countries. By the end of the 1990s, the EU R&D deficit, especially vis-à-vis the U.S., had become one of the major factors influencing the 2000 Lisbon strategy (Rodrigues, 2002). The subsequent 3% R&D intensity target set in Barcelona reflected a benchmark with competitor economies that was implicitly based on the belief that more investment in R&D would result in more innovation and a stronger growth potential. In other words, macroeconomic R&D intensity was considered to be a key input indicator.

The Barcelona target has remained high on policy agendas across the EU, influencing policy making at the national and European levels and has set an important aspiration. Nonetheless, despite this political attention, R&D intensity at the EU level has remained essentially flat since 2000, with aggregate R&D below 2% (Figure 1.2). The EU-27 is lagging behind the US, Japan and South Korea, and more broadly the OECD average, in terms of R&D intensity mainly due to a lower level of R&D funded (and performed) by the business sector.

The level of R&D intensity differs of course widely among EU countries (average EU R&D intensity for 2006 is 1.84%, *Key figures*, 2008 – figure I.1.3). Some Member States (MS) are among the most R&D intensive countries in the world while, at the other end of the spectrum, a number of them have an R&D intensity well below 1%. Since 2005, each Member State has set a national R&D intensity target (*Key figures*, 2008 – figure I.1.6). The targets differ, as do the achievements of individual MS. If all MS were to reach their respective R&D intensity targets, the EU-27 as a whole would have an R&D intensity of 2.5 % in 2010 (*Key figures*, 2008: 29).

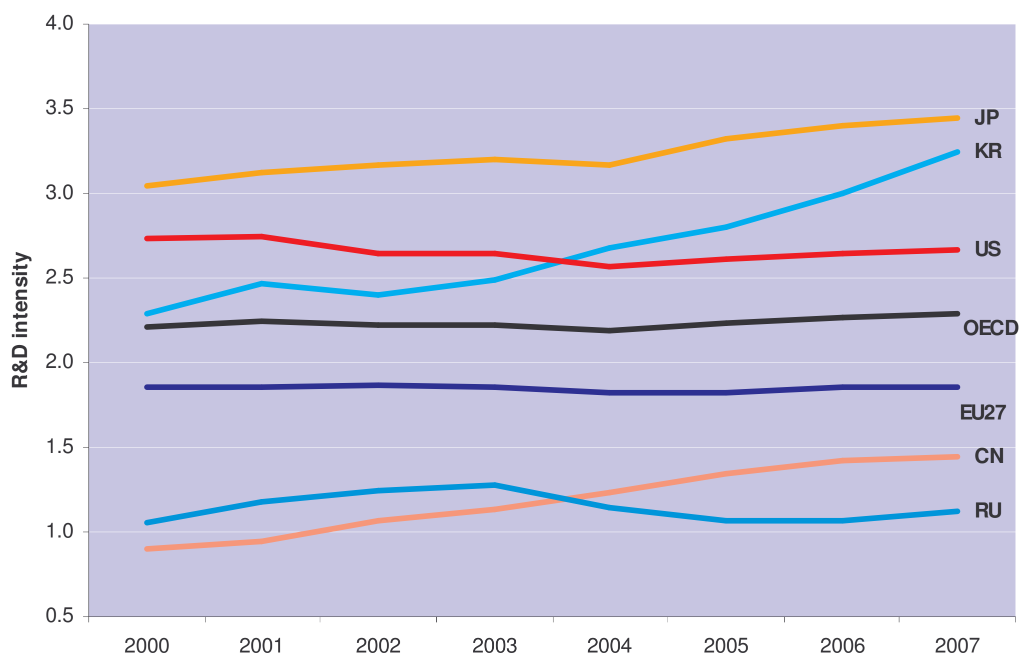
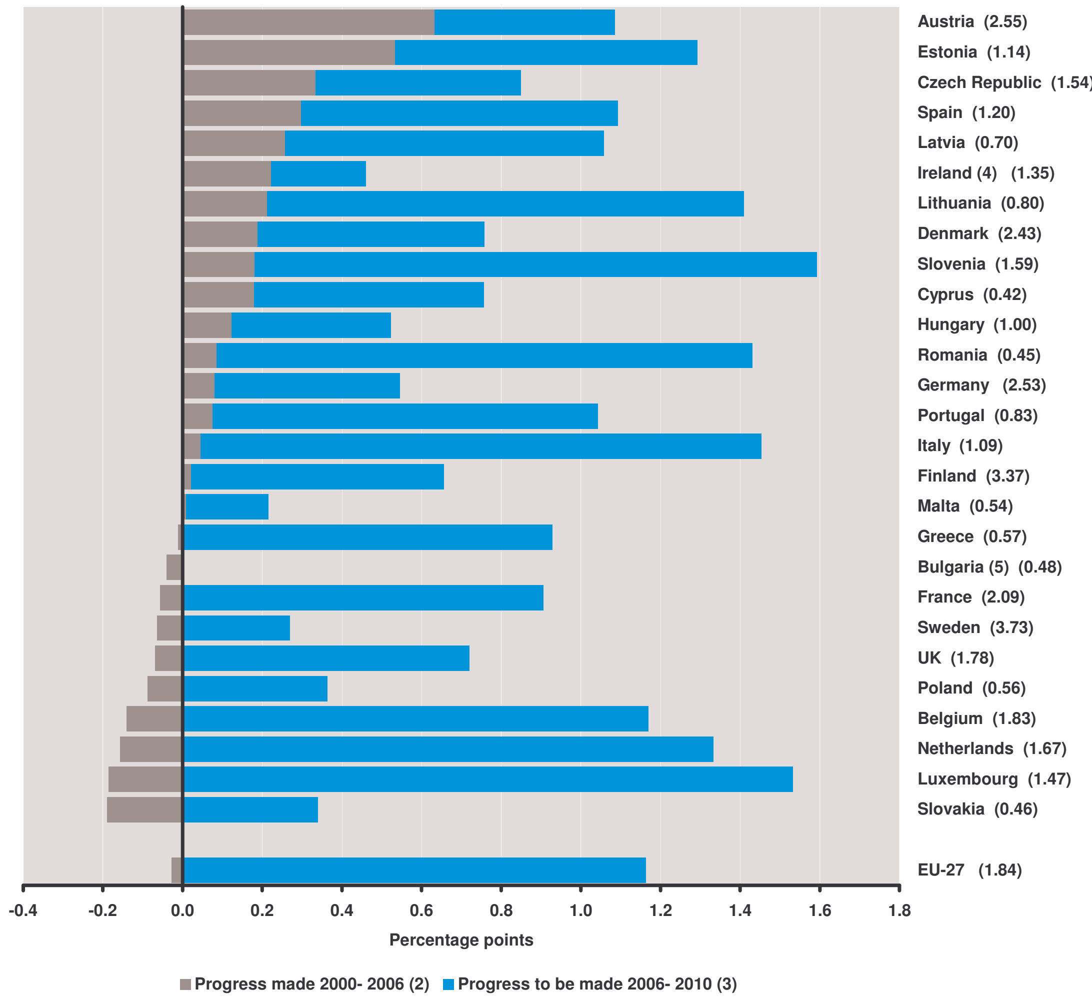


Figure 1.2: Evolution of R&D intensity, 2000-2007.
Source: UNU-MERIT
Data: Eurostat, OECD

The intensity of business funding of R&D has increased almost exclusively in Member States where this intensity was already low or very low (*Key figures*, 2008). In high-income EU countries business R&D intensity has been flat or has decreased; the upward trend observed during the end of the 1990s has been short-lived.

Figure I.1.6 R&D intensity - progress towards the 2010 targets (in percentage points); in brackets : R&D intensity, 2006 (1)



Source : DG Research
Data: Eurostat, Member States
Notes: (1) IT : 2005; IE, AT, SK, FI : 2007.
(2) IT : 2000-2005; IE, AT, SK, FI : 2000-2007; EL : 2001-2006; FR, HU, MT : 2004-2006; SE : 2005-2006.
(3) IT : 2005-2010; FR : 2006-2012; UK : 2006-2014; EL : 2006-2015; IE, AT, SK : 2007-2010; FI 2007-2011.
(4) IE : The R&D intensity target for 2010 was estimated by DG Research.
(5) BG has not set an R&D intensity target.

Figure 1.3: R&D intensity: progress towards the 2010 targets (in percentage points).

Figure 1.3 illustrates the wide variety in progress towards the 2010 target made in each MS, and the progress still to be made. Here too, the impact of the crisis is likely to have some perverse effects. The first country figures being published on R&D intensity for 2008, show significant, sometimes even dramatic increases in R&D intensity (Iceland, Ireland, Austria) in some of the countries hardest hit by the financial crisis[37].

[37] See e.g. in the case of Ireland: http://www.proinno-europe.eu/index.cfm?fuseaction=nwev.NewsReader&news=2636&lang=EN&ParentID=0&topicID=90

The most recent Eurostat R&D data available for all EU MS, as well as for the US, Japan, Korea, China and Russia, cover the year 2007 (Figure 1.4).

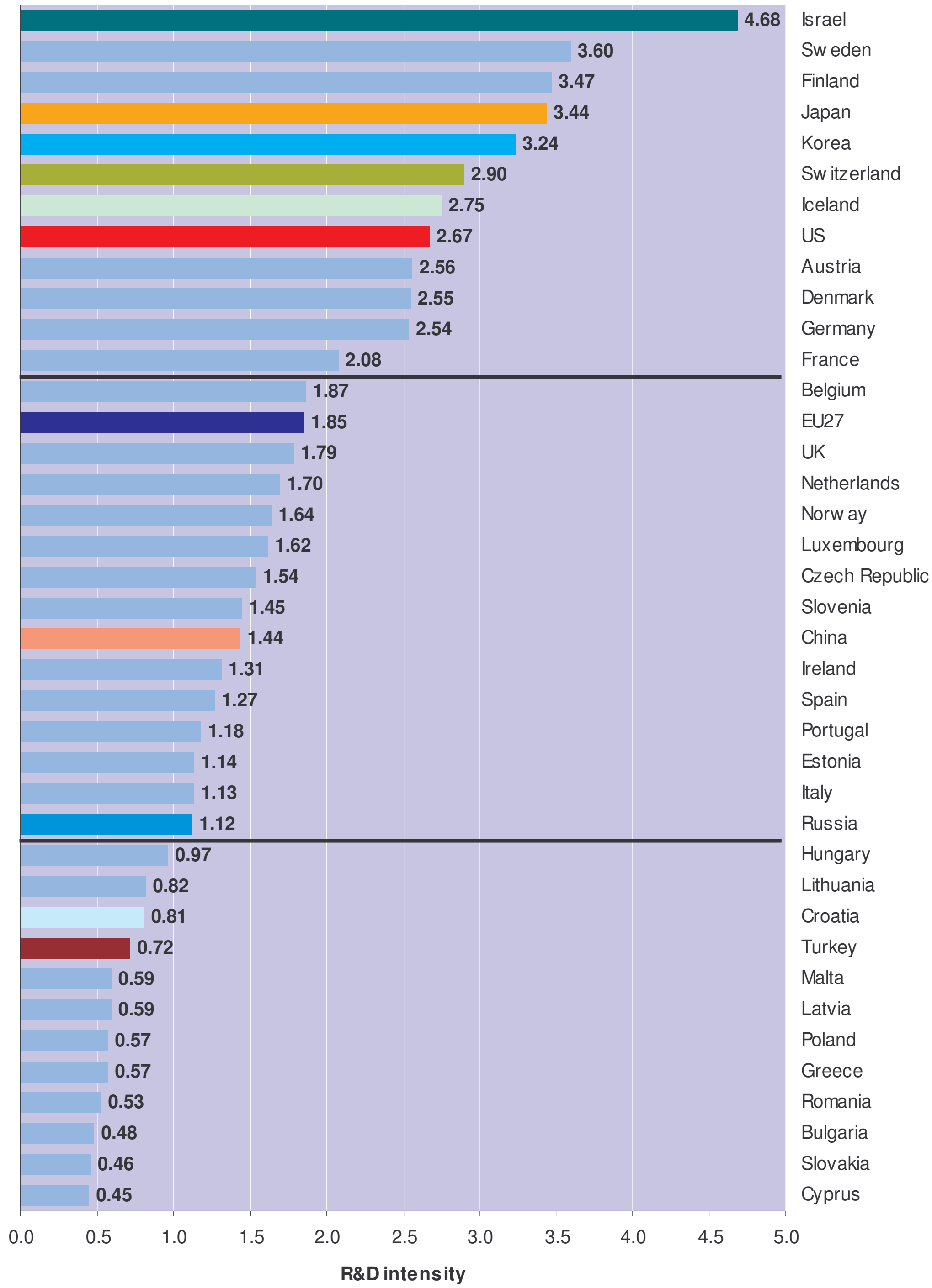


Figure 1.4: R&D intensity in European countries (GERD as % of GDP, 2007).
Source: UNU-MERIT
Data: Eurostat, OECD
Notes: CH: 2004, IT: 2006

The figure shows 3 groupings of countries: high R&D intensive countries (more than 2%) with only 6 MS, average R&D intensive countries (between 2 and 1%) with the majority of MS, and low R&D intensity countries (less than 1%), primarily New Member States (NMS).
The difference in total R&D intensity as illustrated in Figures 1.2 and 1.4 between the EU and the US is almost exclusively due to differences in levels of private sector funding of R&D as illustrated in Figure 1.5. In 2006, China actually overtook the EU in the industry-financed funded R&D which grew substantially over the last four years for which data are available. By contrast, the intensity of business funding of R&D in the EU has remained more or less stable: from 1.05% of GDP in 2000 to 1.00% of GDP in 2006 (*EU Key figures, 2008*). As a result the gap with the US and the OECD average has further widened over the period 2004-2007.

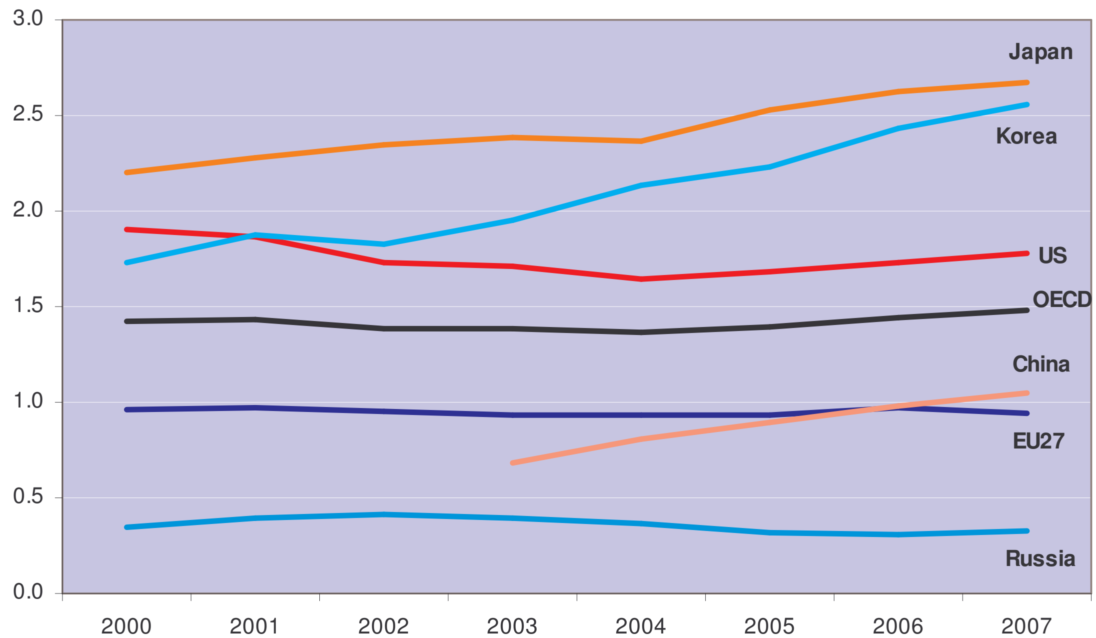


Figure 1.5: Industry-financed GERD as a percentage of GDP (2000-2007).
Source: UNU-MERIT
Data: OECD

With respect to publicly funded R&D the picture looks very different, as illustrated in Figure 1.6. The EU R&D intensity has slightly declined between 2003 and 2007 from the level of 0.6% of GDP, well below the Barcelona target of 1%. The US and Japanese publicly funded R&D intensities have also declined, whereas Korea witnessed a dramatic increase, likely to reach as non European country the Barcelona target of 1%.

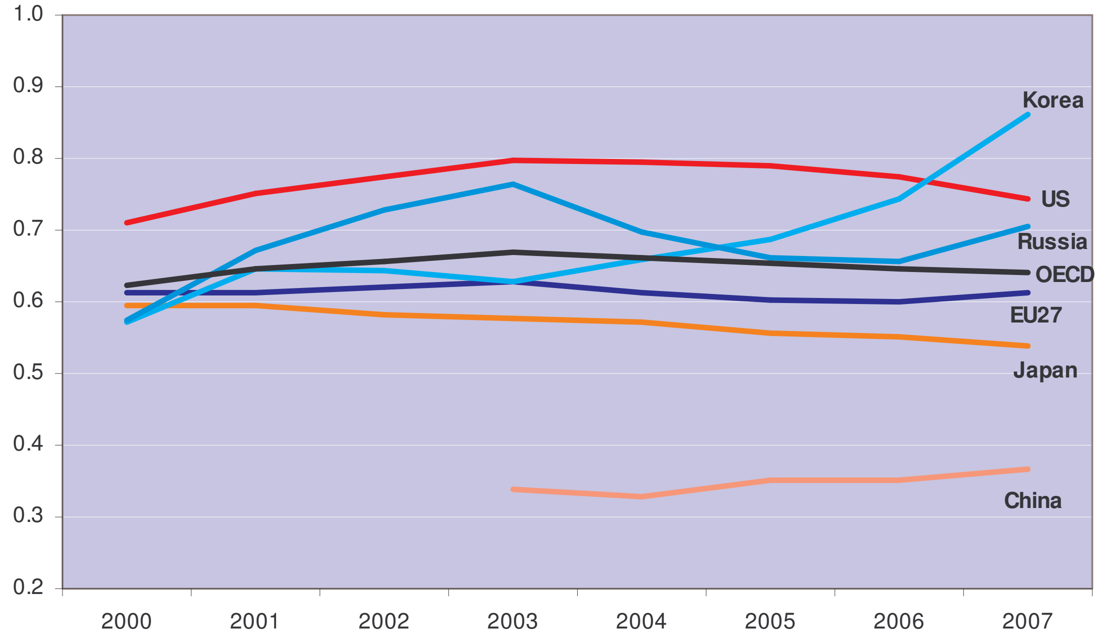


Figure 1.6: Government-financed GERD as a percentage of GDP.
Source: UNU-MERIT
Data: OECD

Private sector investments in R&D are influenced by a wide range of factors ranging from: patterns of economic structure and sector specialisation; the relative concentration of R&D within a small number of large global firms; firms' business models sometimes relying primarily on internal research activities, sometimes on external outsourced research; spatial geographical concentration of R&D; the capacity of smaller firms to grow to significant size while maintaining high R&D investments; the scientific, technical and entrepreneurial qualities of local business environments; economic cycles and regulatory environments; etc.

Quite a number of studies have attempted to define which of these factors best explains the EU's observed business R&D deficit.[38] Moncada-Paterno and Castello and Smith (2009) suggest that economic structure (i.e. sector specialisation) and company demographics play an important role. A French official report has thus attributed the business R&D deficit of France vis-à-vis Germany and Japan to the higher share of mid-high tech industries of those countries (DGTPE 2006). It has at the same time identified a different source for the deficit vis-à-vis the U.S. The share of manufacturing is lower in the U.S. than in France and a substantial part of the deficit comes from a higher R&D intensity in some high tech sectors and in services. Similar conclusions can be drawn from the latest EU *STC Key-figures report* (EU 2008), which shows that the transatlantic business R&D differential is mostly explained by the substantially larger and more R&D intensive U.S. high-tech industry.

The *R&D Scoreboard* (DTI, 2008) identified some 1,400 companies worldwide that invest more than €24.3 million in R&D, with the largest (Microsoft) investing €5.6 billion. The distribution is, however, very skewed, with 63 companies accounting for 50% of the total of €372 billion. Data from the Scoreboard illustrate in general that for the EU there is a low contribution of high R&D intensity sectors to the overall R&D intensity explaining the higher R&D intensity of the US and Japan compared to the EU (Moncada-Paterno and Castello et. al., 2009: 13). This can be

[38] See also and in particular van Pottelsberghe, 2008.

exemplified further using data for the relatively R&D-intensive IT hardware and software sectors (Table 1.2).

	Hardware			Software		
Where headquartered	# firms	Average R&D/sales	Aggregate R&D	# firms	Average R&D/sales	Aggregate R&D
USA	134	9.6%	€36.4 bln	71	10.6%	€20.2 bn
EU	26	13.5%	€16.6 bln	32	9.8%	€3.9 bn

Table 1.2: Number of IT firms and their R&D expenses in the US and EU
Source: Department of Trade and Industry, *R&D Scoreboard*

In other words, EU-headquartered firms in these sectors are not R&D-averse compared to their US counterparts. The "deficit" comes from having far fewer firms making major investments (in the case of hardware) or being substantially smaller (in the case of software). This phenomenon, which we term the EU's "growth paradox", is discussed further in Chapter 4.

Particularly among countries lacking large R&D intensive firms, low R&D spending by SMEs has also been put forward as a way of explaining the R&D deficit. One difficulty with this argument is the need to correct for the share of SMEs in the economic activity or total R&D. This issue has proved relatively difficult to study, but the available results suggest that the propensity of SMEs to spend on R&D (in a given sector) is not a major explanation of low aggregate R&D intensity.

At the national level, it may be noted that the UK for example scores better in Innovation rankings than in R&D rankings. This could be related to the efficiency of the innovation process and/or to the relative importance of non-technological innovation in the UK. In turn, the latter is related to the relative importance of the service sectors in the UK. This sectoral composition however is similar to that of the US, where R&D intensity is much higher.

These different results suggest that the macroeconomic R&D intensity may be considered as much as an output of each national innovation system as an input (van Pottelsberghe 2008).

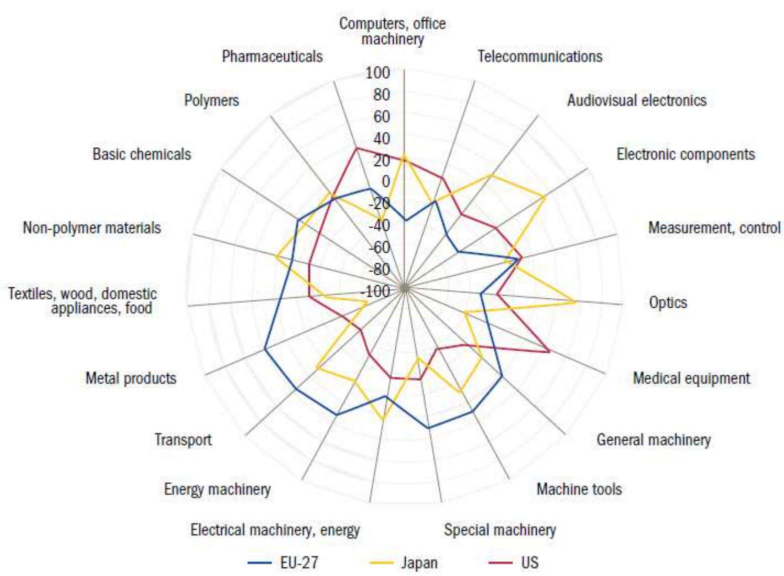


Figure 1.7: Technology specialisation, 2004-05
Source: DG Research (EU 2008)

Additionally, it should be noticed that the EU's academic research system is also not specialised in high tech related activities. First, the EU publications are not specialised in a number of emerging scientific disciplines and in some of the most dynamic scientific fields (EU 2008). Moreover, EU publications tend to have a lower impact than US publications, especially in some key emerging fields (Bonaccorsi, 2007).

Second, the EU inventive activity[39] is less specialised in high technology fields such as 'pharmaceuticals', 'computers, office machinery', 'telecommunications' and 'electronics' than in medium technology fields such as 'general machinery', 'machine tools', 'metal products' and 'transport' (Figure 1.7). By contrast, the strongest specialisation of the US is in 'medical equipment', followed by 'pharmaceuticals'. Japan shows strong specialisation in 'electronics' and 'optics'.

In summary, given the weight of high-tech sectors in the overall level of business R&D intensity, *changes in the sector composition of the economic activity would be required in order to increase R&D intensity in the EU*. If one uses the US as a benchmark, it would seem that there is room for further increases in the research intensities of high-tech sectors in the EU, which are about 20% less research-intensive than in the US (*Key figures*, 2008). A research intensity for high-tech industry in the EU that matched that of the US would therefore also contribute to an increase in overall EU business R&D intensity. These changes would involve seeking to expand the current high-tech sectors, to increase the number of sectors which require high levels of R&D intensity, and to increase substantially the number of large firms carrying out or supporting significant amounts of R&D within the EU.

The data suggest that innovation systems are quite consistent in EU countries. In a number of countries, specialisation in mid-high tech industries interacts with specialisation of the research system in the related scientific disciplines. Put the other way round, it means that in a number of EU countries, both high tech industries and the related scientific disciplines have not really become new growth areas. This diagnosis, along with the evolutions of innovation processes, has important policy implications, which will be addressed below in the concluding section 1.7.

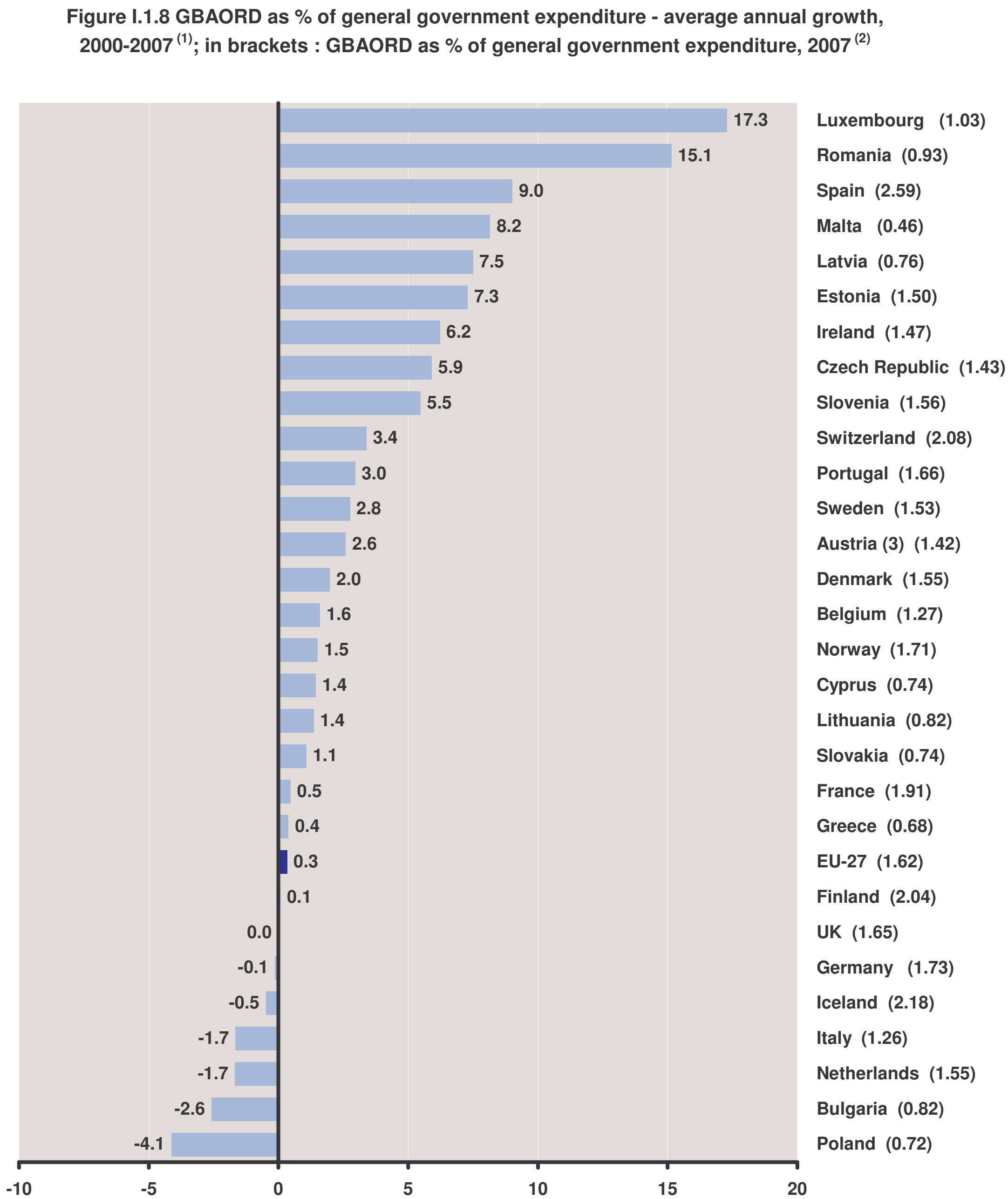
Since 2000, research and innovation have moved up the policy agenda in many Member States, stimulated by the Lisbon strategy and Barcelona target. The schedule and strength of public support of R&D have nevertheless varied across Europe. The share of Government Budget Appropriations or Outlays for R&D (GBAORD) in general government expenditure has been increasing at a rate of 0.3 % per annum between 2002 and 2006, to 1.62 % in EU-27 (see Figure 1.8 from the *Key Figures*, 2008: figure I.1.8). As can be seen in figure 1.8, a majority of Member States (14) have increased direct government support for R&D over the period 2000-2006. However, this intensity has only progressed by 0.3% at EU-27 level due to the decrease observed in Germany and France, and the limited increases in the United Kingdom and Italy (*Key figures*, 2008: 36). Nevertheless, in countries where public R&D budgets were at low levels, the Lisbon Strategy has generally led to a steep change in the political importance attributed to research.

At the EU level, the larger budget of the 7th framework program can also be mentioned as part of the effort to invest more in R&D. Part of this increased support to research has been channelled to business R&D. Member states have used different types of instruments, and especially the increasing popularity of fiscal schemes to support business R&D is worth mentioning (OECD 2007). For example, France reinforced its research tax credit scheme in 2004 and then again very strongly in 2008, when indirect funding should have reached € 4bn[40] and become larger than direct

[39] Measured by patents.
[40] Up from €1.7 bn in 2007.

funding. The UK has extended its fiscal support to R&D whilst Germany and Finland, which did not have such a fiscal scheme are seriously considering introducing one. Some countries, like France and Spain, have also introduced indirect support by reducing social spending related to research staff wages. Overall, indirect support to R&D now represents a substantial share of total support in some countries.

The Lisbon strategy has had an impact on the MS' innovation policies, and this impact has accelerated since the mid-2000s, strongly influenced by the 3% target. A growing number of policies aim to increase R&D spending, especially by private companies. The business R&D deficit has also stimulated policies aiming at promoting public-private R&D partnerships and technology transfer. Overall, the Lisbon strategy has stimulated supply policies aimed at increasing R&D input and the transfer of the results from academic research to companies. More *recent policy initiatives* take into account the evolution of innovation processes, but this trend should be reinforced as explained in the box below with respect to non-technological innovation and more generally in the following section that focuses on ERA. Furthermore, there is a general feeling within the business community (e.g. Swedish Confederation, 2009) that a number of EU and member states' funding schemes are too small and often too complex to achieve the desired results, while the accompanying public policy seems too abstract and science-oriented to justify significant engagement. While the importance of R&D is widely recognised, companies will focus on what this R&D achieves. In this respect, it is appropriate to view the EU's business R&D deficit as a reflection of how the region's *environment attractiveness* is to research investment. The limited attractiveness reflects the existence of other global opportunities and the poor capacity to support the growth of significant new businesses.



Source: DG Research — Key Figures 2008

Data: Eurostat, OECD

Notes: (1) CH : 2000-2004; BE, ES, FR, IT, LV, PL, IS : 2000-2006; UK : 2001-2006; DK : 2001-2007; BG, EU-27 : 2002-2006; CZ, SK : 2002-2007; CY, MT : 2004-2006.

(2) CH : 2004; BE, BG, ES, FR, IT, CY, LV, MT, PL, UK, EU-27, IS : 2006.

(3) AT : GBAORD refers to federal or central government expenditure only.

(4) Hungary is not included due to unavailability of data.

Figure 1.8: GBAORD as % of general government expenditure – average annual growth 2000-2007

Box 1.1: Non-technological innovations and public policy

There is considerable evidence demonstrating the growing economic importance of non-technological innovations. Moreover, non-technological innovation tends to be quite open. Much of the economic growth in the US in the 1990s and early 2000s has been attributed to innovations which have been consequent upon understanding how to use IT most effectively (leading, for example, improved supply chain management; improved services to customers; etc.), rather than deriving directly from specific new technologies (Conference Board, 2009). There are also new business models that have emerged from the organisational innovations and community-based approaches that become possible in networked economies.

There is growing awareness (see, e.g., reports by the UK body, NESTA) that such innovation often differs fundamentally from innovation in advanced manufacturing, but so far no agreement has been settled about which forms of innovation matter most in services or if and how policy should support them. Nonetheless, many of the reorganisations undertaken by firms in recent years can be understood in terms of bringing traditional "technological research" much closer to those other corporate activities that drive non-technological innovation.

It is a mistake to see service innovations as being somehow distinct from the product and process innovations of manufacturing: all are required and they are often interdependent and linked. Rather than being mutually exclusive, both reflect the high-value, dynamic, creative activities that exemplify a KBE and the value added therefore lies in the combination rather than the single elements. Firms combining technological innovation and non tech innovation achieve the best results in terms of productivity improvement.[41]

It is thus important to incorporate new models of innovation within policy structures that have developed around linear models, which reflect the view that scientific research leads to technological development and thereafter combine with other non-technological activities that eventually lead to innovation. Very little public research funding so far reflects a belief that non-technological innovations can be as important for our societies' development as the innovations that derive from scientific progress.

1.6 The funding of higher education

Comparing aggregate funding in the EU versus the US

Next to the business R&D deficit, there is another deficit Europe faces: that of higher education funding.

Data on the total percentage of GDP devoted to higher education indicate a very sharp difference between the US and Europe as a whole, as well as individual MS. In the US, approximately 3.3% of GDP is spent on higher education, while in the EU27 the figure is only 1.3%[42]. In Euros per student, this translates into an even more staggering difference: 36,500 in the US versus 8,700 in Europe. While Japan is closer to the EU numbers in terms of GDP percentage with only 1.1% of its GDP spent on higher education, it still represents 13,800 Euros per student.

[41] See Figure 1.7; the interactions between technological and non-technological innovations are supported by empirical studies based on CIS.
[42] These numbers can differ a bit due to computational conventions (e.g. in Figure 1.9 the corresponding OECD estimate is somewhat lower), but the order of magnitude is very clear.

As in the case of R&D, the difference mainly comes from private sources: in the US, the 3.3% are the result of 1.5% of public funding and 1.8% of private funding, while in the EU the corresponding numbers are 1.1% and 0.2%. However, it is striking to observe that even public funding in the US is higher, and it is even more true as far as absolute numbers per student are concerned: 16,600 Euros in the US versus 7,300 Euros in the EU.

One may note that bridging this gap involves difficult choices, which the financial crisis is likely to further exacerbate. Public funding will be under stress in a large number of MS and the gap in private investment originates mostly from contributions of student fees. Other private donations tend to benefit only a small number of universities and revenues from activities such as spin-offs, licensing and consultancy rarely provide more than 10% of university budgets. It leads the EG to make an explicit recommendation to set a new European 3% knowledge investment target. One for which governments have actually a direct responsibility: a 2% higher education target which can be achieved either through increasing public funding or through larger private contributions from e.g. student fees; and 1% of public research funding, part of the Barcelona target, where overall Europe also lags behind as was already highlighted above (Figure 1.6).

As illustrated in Figure 1.9, combined this new 3% target is still well below the corresponding figures for the US, Canada and remarkably also Korea which has caught up rapidly over the last decade with the US.

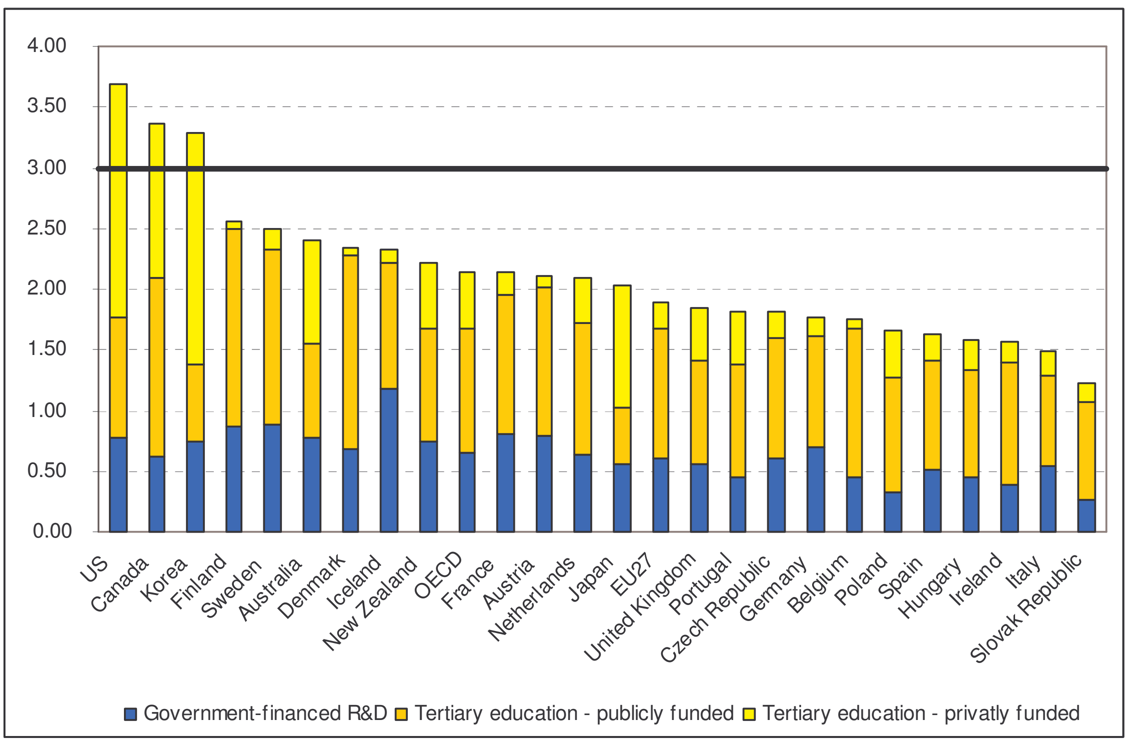


Figure 1.9: Expenditures on higher education and public research as a % of GDP (2006)
Source: UNU-MERIT
Data: Eurostat, OECD

At the same time and in contrast to Figure 1.4, representing total R&D intensities by country, none of the EU MS actually appears close to this new knowledge investment target. Even traditional leading European countries such as Finland or Sweden witness a substantial gap. In short, the proposed new 3% knowledge investment target has a number of clear policy advantages over the previous Barcelona 3% target.

First, it focuses directly on what governments and policy makers are directly responsible for. Clearly and as discussed above, the 3% Barcelona target has had a significant impact on MS' research and innovation policies. A growing number of policies have been introduced aimed at increasing private R&D spending and at promoting public-private R&D partnerships and technology transfer. But ultimately the influence of such policies on Europe's business R&D deficit and on approaching the Barcelona target can only be indirect. As an input target, it has therefore major drawbacks. By contrast the proposed new 3% knowledge target is directly under the control of governments, whether in terms of funding or in terms of setting the funding rules such as in the case of tuition fees. This is a target for which governments and policy makers can hence be held both responsible and accountable. The proposal here is to set this target for 2020.

Second, none of the EU MS is near or likely to come near to this target in the years to come. In political terms the target offers thus credibility. All countries are being challenged to either find own public resources to increase such knowledge investments, alternatively to call upon private resources to invest in individual's future human capital. By leaving the latter to the individual choices of MS, the target provides also sufficiently political freedom to MS to decide how they intend to try to achieve reaching the target by 2020.

Top university funding

Of course one major problem with the above aggregate data is that they lump together very different higher education institutions, from community colleges to research universities. To address this problem, Aghion et al. (2008) sent a questionnaire in 2006 to the 200 European universities belonging to the Top 500 universities of the "Shanghai Ranking" concerning their size, funding and governance. Like all university rankings, the Shanghai ranking is not without its limitations (in particular, it focuses solely on basic research and it under-represents social sciences and humanities). However, it does select a broad sample of European research universities based on an array of indicators of research excellence (Nobel Prizes and Field Medals, articles in Science and Nature, citation counts, etc).

More than 30% of these 200 European universities did fill the questionnaire, which allowed Aghion et al. (2008) to discuss data concerning 10 countries. While details are available in their "blueprint", let us stress here some of the most relevant highlights.

First, there is a lot of heterogeneity between the top research universities in Europe:

- The Southern European universities (Italy and Spain) are very large (more than 40,000 students) but are not well-funded (7 to 10,000 Euros per student).
- Those in Sweden and the Netherlands are of average size (20 to 25,000 students) and are better funded (16 to 20,000 Euros per student).
- In several other countries, the universities are of similar size but have lower levels of funding (9 to 12,000 Euros per student): Belgium, Denmark, Germany and Ireland.

- Finally, the UK and Switzerland have small (10 to 15,000 students) and very well-funded top research universities (around 25,000 Euros per student).

Interestingly, while Europe is more "egalitarian" in its university funding than the US, the UK is an exception here: while in aggregate numbers it is not generous in its higher education funding (1.1% of GDP in total), it does manage to direct significant resources towards its top universities. By contrast, Switzerland is a country which funds very well its higher education system in general.

Note also that these numbers have to be interpreted cautiously, in that they concern universities only, and not total basic research funding: for example, while German universities are not generously funded, this country also funds basic research through the Max Planck institutes.[43] It explains also why it is best as in the case of Figure 1.9 to combine expenditures on basic research funding with higher education funding.

It is also interesting to analyze the structure of university budgets. Aghion et al. (2008) report the following facts:

- All countries have a 60-70% share of public core funding, except the UK and Ireland, where it is 35-40%.
- These latter two countries have significant budget shares coming from student fees (23-32%); fees are also non trivial in Spain and Italy (12-16%), while they are below 7% elsewhere, and even near zero in Scandinavia.
- Finally, budget shares coming from competitively-allocated research grants are of the order of 15-22%, but they are lower in Spain and Italy (10-12%) and much higher in Sweden (34%).

While the importance of public funding across Europe is clear, Aghion et al. (2008) stress the diversity of university funding across European countries, a point we come back to in Chapter 3. In fact, countries which are quite successful in the Shanghai ranking, like the UK, Sweden and Switzerland, follow quite diverse patterns. For example as far as student fees and governance is concerned – the UK is closer to the "US model" of more private, more autonomous universities. One can thus not speak of a "unique route to success".

1.7 Conclusions: Globalization and the Lisbon agenda

Over the last decade the Lisbon agenda as subsequently revised (2005) has been carefully monitored by the European Commission and has attracted high level political attention from the Council and the Parliament. The ERAWatch programme has produced a large number of careful reviews of national policies and implementations. Although another Expert Group is explicitly dealing with the issue of the Barcelona target, it might be useful to reflect on this target from the perspective of the two drivers of globalization and agglomeration considered here.

In the previous section, the available data and analyses were briefly discussed. By and large, the existence of the 3% aggregate "Barcelona" goal for the EU had the merit of attracting top level political commitment at government level and has supported a large effort by stakeholders to push towards the increase in R&D expenditure. As a result, over 2000-2006, R&D expenditures increased in real terms in practically every Member State (14.8% for EU-27) while the R&D budget

[43] The same argument could be made for France and CNRS. Note however that Aghion et al. (2008) do not report results for France, due to a poor response rate to the questionnaire, as well as lack of comparable data as far as budget figures were concerned.

as a share of total government expenditures increased in 20 out of the 27 Member States. However, privately funded R&D remained more or less flat, when increasing this part of R&D was a major part of the Barcelona goal.

Interesting in this context is the relation between the globalization and agglomeration drivers discussed here and the possible *lack* of incentives for private investors to increase their share of funding towards the 2% of GDP target in the EU over the last decade. Could it be that, while the core of the Barcelona policy target was aimed at increasing the share of R&D funding from private sources, the overall drivers have been working in more or less the *opposite* direction. Let us put forward a few stylized hypotheses, discuss the evidence in favour of them and try to derive their implications for private investment in R&D.

<u>Hypothesis # 1</u> *The circulation of knowledge at world level is larger and faster.*
Globalization means that markets are larger, hence that the private rate of return for introducing new products, if the R&D cost is fixed, is larger. At the same time, however, the private investment is less appropriable. Given a larger circulation of knowledge, companies may try to absorb external knowledge without having to pay the full costs for it. Profit-oriented companies may hence have *fewer* incentives to invest private resources in R&D.

<u>Evidence</u>: While there are pieces of evidence in favour of this hypothesis such as the reduction in the share of industrial R&D devoted to *basic* research in many of the global firms and a growing emphasis on development and design, more easily appropriable, overall at the world and OECD level there is ***no*** evidence of any reduction in private R&D investments as was highlighted in Figure 1.5 above. However, with respect to Europe, there is evidence of a growing deficit in business-funded R&D compared to the rest of the world.

<u>Hypothesis # 2</u> *Companies increasingly outsource R&D outside national borders.*
The impressive decrease in communication costs has made the allocation of activities in the value chain more efficient according to principles of global dynamic efficiency. This has meant that large multinational companies have increasingly allocated some of their R&D activities, and in particular development centres in places where the conditions of skilled labour markets, cost levels, and infrastructural endowment are most favourable to their business objectives.

<u>Evidence</u>: The literature on the internationalization of R&D illustrates how this trend has become a truly global trend. The implication is that European companies do not necessarily carry out R&D in Europe, but rather and increasingly so in emerging markets. However, empirical evidence suggests that the outsourcing of R&D outside Europe may well be complementary with, and not merely a substitute for, investment in Europe. Nevertheless, the balance between inflows and outflows of R&D is still negative.

<u>Hypothesis # 3</u> *Researchers are more mobile and select their place of activity on a world basis.*
Mobility of researchers favours those agglomerations that are visible and attractive on a global basis. Training European researchers without offering career prospects means ultimately subsidizing the research systems of other regions in the world, producing skilled young people that will generate first and foremost value elsewhere.

<u>Evidence</u>: The evidence on the attractiveness of European universities and more generally of the research systems at postgraduate level and post-doc level is not particularly encouraging. On the contrary, the flow of European researchers outside Europe is growing over time. In other words, in the overall brain circulation, Europe, compared to the US and Asia, does not receive a large gain.

Hypothesis # 4 *Within the present crisis governments have difficulty in justifying an increase in public support for R&D.*
This hypothesis does not refer to companies but to governments. In a certain sense, the globalization driver makes it more difficult to argue for an increase in national R&D spending, if the main argument is one based on strengthening national competitiveness. Governments might say to taxpayers: we need to spend more on R&D because there is global competition, but taxpayers have the intuition that spending more produces benefits at national level *only* if the country is already strong in the particular scientific and technological field; otherwise the additional expenditure will benefit other countries.

Evidence: Certainly within the framework of the present financial crisis, there will be concern to make sure that demand stimulation measures benefit first and foremost the national economy. A nice illustration is the current competition amongst MS in providing R&D tax incentives.

Let us discuss the implications of these hypotheses.

If H1 and H2 are valid and significant, one would see a reduction in privately-funded research, and in particular in the most risky R research parts, not only in Europe but everywhere in the world and certainly also in the US. As the evidence shows, this does not consistently seem to be the case. On the contrary, it remains a particular feature of Europe, where industry-financed GERD as a percentage of GDP has remained more or less flat over the last decade. Therefore we need additional explanations.

One possible factor is that, under a globalization trend, the rate of return of R&D for private companies is also a function of the size of the domestic market. Insofar as internal markets for innovative products remain fragmented in Europe, there may be a lack of private incentives for firms to carry out R&D here because the profits from innovation may be eroded by higher marginal costs in market penetration. A possible related explanation is that firms in the typical high-tech sectors do not grow in Europe up to the point they might become big R&D spenders, while this is much more the case in the United States. We will come back to this issue in more detail in Chapter 4, but the key point is that business strategies are increasingly global in design and integrated in their execution and regions therefore compete on many fronts for investment. The average age of big R&D spenders in Europe appears much higher than in the US: few large European high tech companies were created over the last couple of decades; most of them are large incumbents with a long history of mergers and acquisitions in medium-tech sectors. In a globalized world, being able to grow fast in fast growing industries is crucial, something which appears not to have been the case for Europe. While globalization did not directly reduce the private incentives to carry out R&D across the rest of the world, it seems to have done so in Europe for rather specific reasons which warrant further analysis of the shift towards open and global innovation business processes (see Chapter 4).

Here though, we can conclude that under these circumstances the Barcelona objective, while useful in increasing policy awareness of the European business R&D deficit and stimulating MS' policies aimed at increasing private R&D investment and the transfer of results from academic research to companies, was up to a point also misguided. It placed the burden of increasing Europe's overall R&D intensity on the shoulders of European firms during a period characterized by an increase in knowledge spillovers and under domestic conditions involving severe fragmentation of markets for innovative products. In this sense globalization is likely to have made the achievement of the 2% private goal more difficult, precisely at the time when it was assumed as an overall framework for action. In particular, and as detailed above in section 1.5, the 2% goal would actually necessitate a substantial change in the economy structure of the EU towards more research intensive sectors, a process which would take much longer than a couple of years.

If H3 is valid and significant, the European Research Area should be a crucial policy goal, to be emphasized and strengthened. In fact, it follows from the argument on globalization of knowledge that Europe has an imbalance between the creation of qualified human capital in universities (data show that the number of graduates and PhD's in science and technology is comparable or larger than other areas in the world) and the valorisation of such capital. To gain an advantage in a knowledge regime characterized by a larger mobility of qualified human capital, it is important to become attractive, not only to produce human capital internally. Globalization makes the goal of a large and attractive research area, encompassing *both* public and private sector, not less important, but dramatically more important.

Finally, if H4 is the case then we have to build a new argument to support public investment into R&D. In a global world, arguments based on competitiveness are not enough. They also increasingly lack credibility. Citizenship, as argued in the Epilogue of Part I is the key here. We have to invest more in R&D because living in the knowledge society requires moving the threshold of knowledge up on a continuous basis. It is here that our EG proposes a new EU 3% knowledge investment target to be achieved by 2020. If European citizens are not prepared either through taxes on through their own savings to invest in higher education and research, Europe as one of the richest regions in the world will ultimately not be able to address the many large social and global problems confronting Europe and the world such as climate change, energy dependency, food security, immigration, poverty, and many others. The solution of large social problems will require both new knowledge *and* adaptation: but it will not be possible to adapt without investing massively into new knowledge and research.

Summing up, globalization made the European goal of a 2% private investment target in R&D less likely and the political argument based on competitiveness less credible. Asking for more private investment in R&D from European business without at the same time offering a credible plan for further integrating, or at least harmonizing European markets in new products and services, was to some extent missing the point. The following list represents examples of aspects that ultimately will need to be taken into account in an augmented ERA:

(a) companies invest private resources in R&D only if they consider the final market large enough to recover the investment;
(b) having many national markets fragmented by regulation, language, and entry processes, implies an increase in marginal costs of the overall "time-to-market" decision, leading to a reduction of the rate of return to research investment;
(c) the institutional separation between European research, leading to proof-of-concept or prototype stage, European innovation policy and European competition policy, is a major source of uncertainty, seriously preventing companies from investing;
(d) research policies need to be accompanied by reduced red-tape and institutional streamlining through frameworks for economic remuneration, non-monetary incentives, employment conditions, etc., and open up for more flexibility to individual research institutions how to sharpen their profile and strength in specific niches.

The Lisbon strategy and the ensuing Barcelona targets have undoubtedly contributed over the last ten years to much stronger support in MS for R&D activities and for fostering innovation in firms. R&D fiscal incentives have increased in most MS and have been created in MS where they did not exist before. Furthermore, MS have adopted a number of measures to promote the creation of technology-based firms and encourage their growth, to favour collaboration with the public research base, to develop science and technology clusters. However, all these measures have been taken without much consideration for their overall European impact. On the contrary, the recent national MS' measures taken with respect to R&D tax incentives raise major new issues with respect to intra-European competition with respect to R&D location.

One may conclude that the arguments put forward under this first Chapter on globalization and agglomeration of research and innovative activities highlight the need to refocus European research policy. Less focus on national competitiveness, internal networking, generic goals of structural internal integration and the static division of labour between the public and private sector; more focus on cooperation, partnerships with third countries, access to global flows of knowledge, dynamic partnerships between public and private. And finally, a clear and explicit role for European governments to take their responsibility, even in the difficult times of fiscal austerity to come, to invest 3% of their GDP in knowledge approximated here through public research and higher education. A new, more realistic and politically credible target, can create the financial conditions for the ERA to come to full fruition over the next decade.

Having discussed at length in this first Chapter some of the internal contradictions and limits of European policies aimed at increasing knowledge accumulation and knowledge diffusion in Europe – what could be called in the language of the economist: policies aimed at increasing the *rate of technical change* in Europe – at a time when the globalization and spatial agglomeration trends of knowledge were precisely challenging such policies, we now turn to the challenge of designing European policies influencing the *direction of technical change* in the next Chapter.

Chapter 2:
Addressing societal challenges

2.1 Introduction

In recent years, the notion of Societal Challenges (often referred to as "*Grand*" Challenges) has been launched in the European arena as a promising concept for mobilizing in a more active way research resources and capacities across the EU[44]. At the same time, a debate has been opened in the research policy community on the need for research to be more responsive to societal needs, addressing complex, multi-disciplinary issues that have strong practical implications.

The notion of Societal Challenges, which the EG prefers to use, applies to societal problems that cannot be solved in reasonable time and/or with acceptable social conditions, without a strong and, in the European case, coordinated input requiring both technological and non-technological innovation, and also, but not necessarily always, advances in scientific understanding. Important examples are, and without any attempt to cover all aspects: - climate change; - sustainable energy and environment; - sustainable city life (mobility, congestion, green car, urban quality of life); - ageing of population; - poverty.

Each of these issues shares most, if not all, of the following characteristics:

- the problem to be solved is primarily social and involves many complex, interacting and often contradictory elements;
- few of these elements can be solved by using a unique disciplinary approach, either in scientific research or in technology, but require knowledge from disparate actors and a strong integration of a large array of technologies, creating various types of coordination failure and system failure in the innovation chain;
- the eventual solution of these societal issues is likely to involve significant changes in the organization of society and in the daily life of communities, requiring non-technological innovation through adaptation and learning;
- nonetheless, the required levels of performance also demand substantial improvements in technology (e.g. in energy generation and conservation, and in the use of IST for mobility and health technologies), and also benefit substantially from advancements in fundamental science (e.g. in new matter physics for energy materials, or in new algorithms for mobility management)[45];
- the final demand is huge in size, but often only latent or potential in market terms, thus creating lack of incentives for private investment, at least in the short term;

[44] As a matter of fact the Terms of References of the EG refers explicitly to the need for the EG to: "analyse how to build upon the Grand challenges approach to promote EU competitiveness and how to optimize the use and the functioning of the Joint Technology Initiatives."

[45] Some things need step-change improvements in technology, others though don't: much energy efficiency of housing would use available technologies, as well delivery of medical care to the poor, etc. The issue is primarily the performance of systems; the question of the need for breakthroughs in technology should be formulated in terms of whether some component within the system is a critical structural "hole", into which S&T investment could be poured to transform the whole system's performance.

- the final demand is also usually fragmented in many regional and national markets, subject to a wide variety of standards and regulatory conditions, creating a large unfulfilled potential for growth[46] ;
- a significant role in final demand is played, directly or indirectly, by public procurement, although not necessarily in all cases;
- private investment is hampered by several externality conditions that limit consumers' willingness to pay;
- the development of effective policies is very demanding because of the need to combine supply-side with regulatory and demand-side goals and tools; and
- views of what constitute politically and socially acceptable solutions may change considerably over time (e.g. use of nuclear versus renewable energies; urban design; the balance between health care and quality of life; personal freedom).

The determination to address such challenges will represent a strategic re-orientation of European research and innovation policies, not just the introduction of new instruments, such as the JTIs, at the operational level. It must enter into many mainstream policy areas in addition to research and innovation.

2.2 Rationale for a societal challenge re-orientation of European research and innovation policy

There are a number of reasons which explain the timing of this re-orientation.
First, the Challenges are both real and important, and it is unlikely that they can be solved without a co-ordinated approach.
Second, such an approach can provide a strong driver for improved policy coordination, particularly between research policy and innovation policy, which is in Europe a particularly difficult and unsolved issue.
Third, addressing Societal Challenges seems a sensible response to the increasing social demand for relevance and impact of research, as well as for global justice for all. The approach can increase the legitimacy of science and technology and investments therein, and foster better relations between the scientific communities and the public opinion[47].
Fourth, Europe has strengths in many relevant scientific areas (e.g. in energy research, climate change, virology, epidemiology, food science) and is also internationally competitive in areas of technology that seem likely to underpin successful attacks on these challenges (e.g. renewable energies, waste recycling, water management, urban transport, vaccines). This means that, if large world markets do emerge to address societal issues, Europe can play a leading role and expect to benefit, provided it is properly organised and equipped to do so.

A Societal Challenge dimension would, in other words add a new objective to public policy, whereby research and innovation are seen not as ends in themselves, but as a means to a wider goal, defined as a societal benefit. The aim would be to foster those activities that have greatest impact on achieving the societal challenge, and not necessarily to increase research and improve innovation across the board. In contrast to existing policies, this approach implies a focus which is neither

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[46] Think for example at how different national rules for reimbursement in public health care systems make markets for new biomedical technologies sub-critical, particularly for start-ups.
[47] Notwithstanding that there always will remain areas of intense conflict even with respect to the legitimacy of science in relation to societal challenges. That is why the EG also prefers the use of the word Societal as opposed to Grand. The control of global warming is a good case in point. Global warming is undoubtedly a major global Societal Challenge, but it has not legitimated the science of climate research in the eyes of the public, on the contrary. The danger here is that the greater its social salience, the larger the number of voluble people who might say global warming is a plot by the conspiracy to create world government.

horizontal nor sectoral, but defined by the societal challenge, i.e. involving the mix of different sectors, markets and other actors that can bring about the changes needed to achieve the challenge. The relevant actors would include companies in various sectors, but also encompass those involved in innovation in public sector and public services, and in setting demand side and regulatory and market frameworks that support innovation[48].

However, if the notion of Societal Challenge is not to be purely rhetorical or to serve as a catch-all redefinition of industrial and applied R&D, its meaning must be closely linked to the idea of some more societal, demand-driven or mission-led innovation policy. While the original formulation of mission-led policies was developed after the Second World War and dealt with critical or strategic technologies, the current approach is clearly different[49]. The following features appear particularly relevant (Gassler et al, 2008, pp. 214-15):

- the identification of thematic fields is not done following technology push approaches, but by combining societal needs with inputs from the technological community;
- priority setting is no longer a top down, centralized process, but an inclusive process involving many social actors, including those who will carry out the actual R&D;
- the diffusion of results to a large audience (not the appropriation by large contractors) is critical;
- incremental innovation and non-technological innovation are recognized as crucial (as opposed to the major technology breakthroughs demanded by the old sorts of mission-oriented policies).

In short, while the definition of a Societal Challenge will be made at a rather macroscopic level – the objectives or challenges are so to say “large-grained” – the microscopic choices about the kind of “fine-grained” technologies to be developed and innovations will be left for markets to determine. So the policy focus has to be not on specific technologies and designs but on broad societal needs and systemic problems and on how to define the approach to these problems and sustain this approach over extended periods.

Historical examples amongst others from the US suggest that this will ultimately have to include strong political support. As Mowery (2006) has forcefully argued: in the case of the US government’s success in “funding the ICT revolution”, this was clearly based on a large consensus that this field was a high priority government “mission” in terms of national security; while conversely the US repeated failures in energy R&D programmes can be traced back to the lack of a strong link between R&D public spending in this area and any (federal) government mission that had broad political support.

The substantial hurdles involved are illustrated by many, well-known failures in European mission-oriented policy initiatives, as well as by the additional problem of political fragmentation in Europe.

[48] Again, the debate on Societal Challenges still has to take place within the research policy community. One might wonder why we haven’t had a Societal Challenge focus in S&T programs before? The political problem surrounding any policy vis-à-vis any attempt at designing a Societal Challenge policy (as discussed in more detail in the Appendix) is that resources are scarce and one would have to rank order the Societal Challenges by (a) their social priority and (b) the cost of solution – under alternative states of knowledge, which implies alternative dated ordering. Since the distribution of benefits of the actions justified will not be neutral with respect to the ordering of the priorities, there will be conflicts that with impugn the science, and the social science predictions of costs and payoffs. Innovation, as common goal is wonderful because everyone can declare that it is good – and then compete to get the funding. Diffusion policy which is central with respect to Societal Challenges is of a totally different nature: each societal challenge will call for decisions about diffusion.

[49] Actually some first ideas developed for the EC can be found in Soete and Arundel (1993) highlighting amongst others the importance of diffusion policies.

One may think of the following:

- The policies for national or European champions in Information Technology in the 1980s failed miserably, with almost all national leaders disappearing from the market, or reducing their operations, in any case never reaching a leadership position (e.g. Bull, Olivetti, ICL, Nixdorf);
- Government-led informatisation plans had a significant impact in terms of technological learning, but usually failed to deliver the expected results (e.g. Minitel in France);
- Large infrastructures have often been subject to huge increase in costs and substantive delays in implementation (e.g. ITER);
- High Definition TV (a digital-analog technology) was at the centre of a large mission-led research programme, which was based on the wrong assumption that the rival technology, all-digital TV, would not be ready to enter the market. When all-digital TV entered the market, the whole HDTV suddenly became obsolete;
- Cross-European public-private partnership rules in terms of profit sharing and responsibilities have been proved to be difficult to establish, as the failure of Galileo as a joint initiative has shown;
- Government and region-led policies aimed at developing the biotechnology industry in a short time frame did not fully succeed in establishing a self-sustainable, long term-competitive industry
- Major government-driven initiatives may fail to attract equivalent interest among key stakeholders (the UK's digital infrastructure for healthcare; some of the programme-integration initiatives introduced with the sixth Framework Programme).

In a certain sense, most policy initiatives failed to deliver the expected results, and most results came either from lack of explicit policy at the European level or from unintended consequences of policies.

What this shows, is that ultimately no "grand" challenge can be translated into the formation of an appropriate coalition of stakeholders committed to significant public and private R&D effort without there also being a broad political consensus, which in the European case must involve national stakeholders. Furthermore, the private sector will only respond to the incentives created by public policies to the extent that the policies are perceived as being credible, lasting and reasonably stable and otherwise fit within established patterns of business risk.

At the same time, the good news is that after the "wars against communism and against cancer" as effective mechanisms for mobilizing abundant resources towards R&D, the case for large programmes in the area of environment and energy is now stronger than ever; most controversial discussions have been closed. One is now approaching a time of much wider political consensus regarding problems and solutions, with the EC having actually taken the lead with its SET plan. Increasingly the environment and energy crisis is being seen as a threat to the whole world, not just the richest countries (Soete, 2009). Two additional features help to make a good case for environment and energy R&D and technologies being one of the most attractive targets for large programmes and strategic initiatives:

- *First*, there is an increasing awareness that R&D in these domains is becoming a central issue (Arrow et al. 2008; Klemperer, 2008; Rosenberg, 2005; Stern, 2006);
- *Second*, the areas of business activities related to environment and energy are starting to represent an attractive source of entrepreneurial opportunities: market forecasts show that global demand for clean technology and environmentally friendly technology is likely to boom over the next decades.

As argued above, as a "grand" Societal Challenge, the environment-energy-climate crisis represents the perfect case for mobilizing research resources and capacities across the EU. At the same time, it is important to develop sound explanations for success and failures in developing such Societal Challenges based policies, supported by theory. Contrary to the examples given above, Europe cannot afford further major failures today in this area.

2.3. Non-neutral policies, distortion and programme design

One important condition for the success of policy addressing a Societal Challenge within the European context will be the ability to shift resources across European stakeholders to more productive use whenever possible, that is to influence not only the *rate* but also the *direction* of innovation and technical change.

This condition implies a non-neutral allocation process with respect to areas for focus and sectors. Departing from neutrality is always dangerous since it implies guessing future technological and market developments. So a central question concerns "programme design": how to make these large mission-oriented programmes less vulnerable to government failures such as wrong choices and winner-picking (see also Aghion, David and Foray 2008)[50].

A first principle is relatively straightforward: it is crucial to be non-neutral in identifying a very broad agenda while being neutral vis-à-vis specific applications and approaches. Mowery and Simcoe (2002) emphasized this point when analyzing US federal policies about Internet: federal agencies always tried to avoid the pre-definition of technology architectures and design but rather allowed the market to discover the best technologies. However, and as is also well-known, the "technology" of the internet was neither designed nor selected by the market, but rather developed and originally deployed in ARPANET and imposed through NSFnet in 1987, which subsequently opened for private commercial use. "Neutrality with respect to commercial applications" proved to be a wise policy principle of the US governmental agencies in contrast to efforts of other governments, such as the French Minitel programme or Britain's national champion policy. In these cases, and in particular the Minitel case, the policy errors covered not just innovation but also diffusion policy: what became crucially problematic was the French decision to totally subsidize its diffusion, thereby entrenching the system and creating a temporary obstacle to the entry of general purpose computers.

Other principles for mitigating distortions created by the provision of subsidies to favoured firms, industries, and other organized interests are quite straightforward:

Complementarities with competition policy as argued below will be central as well as agency independence in providing grants, use of peer review with clear criteria for project selection, payment based on progress and outputs rather than cost recovery. Such programmes also have to be designed in order to foster the entry of new firms in emerging industries as well as building on existing commercial strengths - and not only to help the large firms already in place.

There has been a lot of discussion in the US about the failure to commercialize the results of mission-oriented R&D programmes. Beyond the general problem that many of these results concerned technologies with limited civilian applications, there is also clearly a conflict between the mission requirements of funding agencies and the feasibility of commercializing technologies developed for these agency needs: awards are required to support research that meets the needs of the awarding agencies, yet products under so-called "dual procurement' policies adopted by the

[50] In Appendix 2.1, an example of European programme design is proposed.

U.S. Defense Department in the 1980s developed under the programme are expected to be successful in the commercial marketplace. Thus, there may be a conflict between the goals of procurement and innovation (Mowery, 2007).

Organizing the allocation of resources in this way will not necessarily produce the "big push" (Murphy et al., 1989). Generating a "big push" requires not only an understanding of the basic principles of coordination problems but also getting a detailed grasp of the externalities and the innovative complementarities involved so as to create incentives and allocate resources at the right "places" for maximizing pecuniary externalities and leverage effects.

For example, since technological progress requires both research and the substantial learning achieved through development and deployment, R&D programmes should not be planned in isolation from practical application[51]. R&D may be required to make even a relatively well-developed technology suitable for particular applications and attempts to make practical use of a technology may reveal points where additional R&D would be most productive (Arrow et al., 2008).

2.4 Policy "grand" challenges in Societal Challenges

There are several issues that deserve closer attention if we want European governments and the European Commission to build research and innovation policies around Societal Challenges. These include in particular the three following challenges: the articulation of final use; the problem of technological uncertainty and the impact on competition. These points require more elaborated theoretical treatment and innovations in the design of policies.

Articulation of final use

First of all, demand-driven policies suppose the ability of government, or an agent on behalf of the government (e.g. an agency) to be able to deploy a fully articulated plan that moves backward from expected social results to technology development. In doing this, the role of demand, as materialized in final users is crucial. Final users refer here to both consumers and professional users. The literature on the social dimensions of technology, on human-machine interaction, and on user-experience and interaction design has shown how the adoption and use of technology is dependent on social processes of legitimation, practice, learning and intimacy[52]. An approach based on top down, or technology push models of innovation makes little sense here. Users must, in other words, be involved in Societal Challenges.

However, in most cases, there is no demand in the sense of economic theory, but only a need, often a latent need. People would like to have less congestion in cities, but there are few examples of markets for rights to less congestion, nor is there a clear willingness to pay for such a desired state of affairs (selective motorway tolls are perhaps one example, but this example hardly required extensive R&D). Aged people would like to have a less stressing daily life, but this is made up of dozens of disparate activities, each of which has to be examined in detail.

In addition, it is well known from marketing science and from the literature on product innovation that the stronger the innovation, the lower the ability of customers to spell out the desired attributes of products or services. Asking people is not a solution, because they are likely to tell you

[51] See in particular the point made in the theoretical literature on the diffusion of innovations published in the 1980's by economists such as David and Stoneman; e.g. David (2006: Part 3).
[52] See Dourish (2001), Oudshoorn and Pinch (2003), McCarthy and Wright (2004), and Suchman (2007).

something very similar to what they see in their everyday life. People perceive the need, but this is not enough to articulate the demand side of the problem, particularly if the demand will come from a new generation of users.

Historically, demand-driven innovation policies have been most successful in the case of military procurement. More recently, von Hippel has shown that in private markets it is possible to obtain quite careful information of future products by addressing not the large mass of customers, or potential customers, but a small group of clever and active users, called lead users (von Hippel, 1988).

However, demand-driven innovation benefits in the military field and in the case of lead users share a number of key features that are *not* found in Societal Challenges:

- users are relatively small number, have a clear professional and social identity, can be accessed by producers in a focused and segmented way;
- users are involved in the use of technology very frequently and with high intensity (physical, motivational, emotional);
- users become able to define the desired functions of technologies in quite abstract terms and to decompose functions into sub-functions (task decomposition);
- users are also able to translate desired functions into well defined performances, using an appropriate technical language;
- users have good command of the system-of-use, so that they can manage network externality effects, coming from the interaction between individual use of several people, reasonably well.

Under these conditions demand-driven innovation policies can indeed target a population of users, understand their needs in a quite detailed way, project them onto the future, and use their knowledge to develop future targets for research plans and for innovation goals[53].

All these features are *not* present in societal demands.

Here the needs are diffused among million people, who use technologies in an episodic or non-professional way, have implicit and dispersed knowledge about the use, and cannot articulate their demand for better solutions. Accessing users is painful, slow and expensive. Even worse, the ability of users to articulate the needs verbally is quite limited, so many traditional social science research tools are of limited help, not to say deliberative procedures.

Societal Challenges comprise literally hundreds potential products or services, all of which suffer, more or less, from the problem of articulating the final use and building reasonable technology roadmaps backward from it[54].

A simple technology push approach is in other words not appropriate, because social demand is not already out there, but is created in a complex and open interaction with technology and public policy. In this area, further advancements in methodologies are needed.

A number of companies have addressed this difficulty through use of systematic scenario building and foresight exercises. A range of approaches exist, with different strengths and weaknesses. It is

[53] But of course there are many other public sector demands than just "military procurement". In the EU, more than in the US, public service organizations, including health care, and educational services, as well as local authority housing, public-private urban amenity programs, and most of the ground transportation sector other than automotive vehicles represent an enormous "market". The central problem seems here to coordinate and inform this demand

[54] Perhaps an exception is the health care sector, in which final users may be unable to spell out the characteristics of new solutions, but hospitals and producers of equipment can be involved in a user-driven innovation process. As a matter of fact, anyway, association of patients already play a great role in advancing some medical technologies.

appropriate to mention Shell's long-term use of (non-technological) scenario planning to provide a shared understanding within the corporation of the socio-political context for future energy demand, and Siemens' "Pictures of the Future" which link forward thinking based on roadmaps with "retropolation" of future markets and societal demand obtained from scenarios.

Technological uncertainty

Another crucial difficulty is the increase in technological uncertainty in the last few decades. The acceleration of the rate of technical progress implies an increase in the rate of uncertainty for long term programmes. During the deployment of the programme, new technologies appear that make old choices obsolete and earlier commitments a waste of money and time. But once expenditure has been committed, agents find it extremely difficult to make forward-looking decisions, ignoring the sunk costs[55]. Escalating commitment is the typical outcome, leading to huge cost increases or even the failure of policy.

Technological uncertainty is also the result of a pattern of proliferation of hypotheses in underlying scientific bases, as can be found in many new areas, such as life science, materials science, or information science[56]. In most of these areas, technology and scientific discoveries proceed hand-in-hand. It would be impossible to develop engineering solutions without a deep and analytical understanding of the properties of matter, but that analytical understanding often involves the use of better technology. In many cases, scientific experiment proceeds through reverse engineering of nature, so that artificial manipulation and experimental observation cannot be separated. Under these conditions, new hypotheses are continuously generated in scientific laboratories, and many technological options are consequently opened.

Thus there is only one established technological trajectory in microelectronics, based on silicon technology, but there are still many options open in nano-electronics, based on discoveries in quantum physics about electronic properties of engineered material configurations of many different materials at the nanoscale[57]. As another example, there are few technological options when dealing with turbines, but there are many alternatives when developing solar energy cells based on new materials such as polymers.

After the emergence of these science-based technologies, it would be meaningless to base innovation policies for societal challenges on more manageable but older technologies. But managing nowadays science-based technologies is a great difficulty.

Technological uncertainty increases the option value of waiting. It is better to wait until further research has eliminated inferior alternatives and possibly created new options. But this makes the management of mission-oriented technology policies increasingly difficult and complex.

Technological uncertainty magnifies a peculiar problem in mission-led policies, i.e. the trade-off between commitment and flexibility, as examined in the large literature on contracts and procurement in economic theory. On one hand, one would like to have investment commitment

[55] Witness the widespread pride in Victorian infrastructures, despite evidence of their wastefulness and inefficiency.
[56] The notion of proliferation is introduced in Bonaccorsi (2008) and developed in van Besselaer and Laredo (2009), and Bonaccorsi and Vargas (2009), while Kiss et al. (2009) deal with a similar problem.
[57] Witness this state of affairs the last edition of the Semiconductor Technology Roadmap, the main document used by the semiconductor industry to align their technological expectations for the next 10-15 years. While the dominant technological trajectory (the Moore's law) has been followed (or shaped) consistently for decades, the scenarios are much more uncertain in the next decades. The more we move down the nanoscale, the larger the scientific uncertainty over the physical and electrical properties of materials, the more difficult it is to foresee industrial investment. Interestingly, one of the most predictable industry becomes subject to strong uncertainty (Delemarle and Larédo, 2009).

from firms willing to develop new technologies in the expectation to gain large market shares. On the other hand, it is hard to anticipate the evolution of technology, so that it is wise to keep resources flexible and avoid lock-in along obsolete technological trajectories. Or, put in another way, on the one hand, one wants to avoid 'picking winners', while at the same time reassuring firms that there will be sufficient demand in the future for their technologies. One way to achieve this, appropriate in certain circumstances, is by setting forward-looking standards, such as governments have done recently in respect of building codes and in setting phase-out dates for incandescent lighting. There is also the need to prevent markets from developing "excess momentum" in situations where there are strong positive feedbacks arising from demand-side externalities. In such cases the option value of "delaying" the emergence of a de facto industry standard is large, but a passive policy of "waiting" is ineffectual. Positive procurement strategies to maintain competition between the leading technical alternatives is required (David, 1987).

The central question within the debate on Societal Challenges is ultimately how to achieve compatibility between top-down initiatives and a market-driven resource allocation logic that allows for "multiple decentralized experiments". The logic of a "grand" Societal Challenge programme trying to impose predefined technologies would dissipate the extraordinary power of a free market economy in boosting a very large number of experiments to discover the best technologies. And this is precisely the result one does ***not*** want to see. As Rosenberg (1987) put it in a now famous article: "*in the context of activities that are immersed in a high degree of uncertainty, capitalism provides multiple sources of decision-making and initiative, as well as strong incentives for proceeding one step at a time. The notion that planning and centralization of decision-making are efficient is the opposite of the truth when there is a high degree of uncertainty and when goals and objectives cannot be clearly defined. One of the less-heralded but considerable virtues of competitive capitalism has been the speed with which firms have unsentimentally cut their losses as it became apparent that a particular direction of research was unlikely to prove fruitful. Where funds come from the public sector, by contrast, monies are likely to be spent much longer on unpromising avenues*".

This is what one would not want to lose by building a Societal Challenge programme: the historical creativity of capitalism as an institutional mechanism to encourage innovation in a context of centrality and pervasiveness of uncertainty, as well as the specific ways in which decentralized markets handle the risks associated with the search for new technologies. At the same time, the recent empirical evidence also highlights that firms quickly cut their losses by abandoning major R&D projects in defence more quickly than was the case in public non-military R&D. In the latter, a commitment to demonstrating performance under field conditions is often compelling. In the literature on corporate R&D, one of the themes that has figured in the literature on the advantages of Joint Research Ventures is that the involvement of teams from more than one firm weakens the resistance of research managers to abandoning projects that their labs had initiated. This does not mean that similar inertia would not arise in public sector R&D projects; rather, it suggests the need for some experimentation with joint research "ventures" between public research agencies in different EU member states.

Being non-neutral in identifying a broad agenda is compatible and coherent with being neutral vis-à-vis specific applications. This is why generic instruments (subsidies, tax credits and programmes aiming at increasing private R&D returns) have, in principle, to be available to all firms that exhibit the wish to develop innovations that are in line with e.g. climate change amelioration goals. The goal is to make this area of research and innovation as profitable as possible for private investors, but the challenge nonetheless remains to ensure the desired outcome and not merely encourage grant-seeking behaviour.

Internal market policy

Mission-oriented policies often require the involvement of large, multi-technology companies. The solution of largely diffused, socially relevant issues requires operations that are widely deployed, requiring competences that are normally associated with large companies. Think for example of industries such as energy generation and transportation, infrastructures, electrical equipment, transport, but also medical instrumentation.

In many sectors, these companies operate in custom or semi-custom markets, addressing specific demands formulated in complex technical documents, such as Request for Proposal (RFP), or Request for Quotation (RFQ). Historically, most of these companies grew from national markets, addressing largely public demand at national and local level.

An extremely effective way for protecting national markets has been through controlling technical specifications. In many subtle ways (e.g. sharing technical consultants, hiring former employees from government, influencing technical culture) governments and companies have shaped the demand in favourable ways, and have silently created formidable barriers to entry to foreign competitors. Multinationals adopt a range of strategies in response, including establishing national subsidiaries, usually with large employment, and participating in initiatives to boost national R&D capabilities. One of the most effective ways to protect market share has been to get access to top level technical decision making in customer organizations.

It is honest to admit that this state of affairs has not changed greatly in Europe after the advent of Maastricht Treaty. Although official figures are not available, a reasonable estimate based on expert views of the share of public procurement at national level that goes to foreign companies is in the range of few percentage points.

Why is this state of affair a problem for Societal Challenges? Because there is a striking conflict between, on one hand, market and technological uncertainty associated to large societal challenges, and on the other the need to manage business risk associated with large companies' strategic decisions. The probability to mobilize large private investment into R&D for addressing societal challenges is larger if the final market is less fragmented and more certain. Yet this state of affairs is also a strong obstacle for the entry of new innovative firms or start ups in addressing these needs. For example, these firms may be deterred from entering into public procurement procedures if these are designed in order to favour large incumbents at national levels. The experience of SBIR in the USA, and of related schemes in Europe (e.g. SBRI in UK, SBIR in the Netherlands) strongly suggest that start up firms and small innovative firms may greatly contribute to the solution of social needs, but also that they are subject to severe constraints, that require explicit policy interventions to be removed.

2.5 The dilemma of societal challenges and a Stage-Gate policy model

For the reasons outlined above, purely demand-driven policies of the Societal Challenges type are faced with a dilemma. On the one hand, companies do not invest in the widespread deployment of new applications until there is sufficient certainty over questions such as technology, regulation and market. On the other hand, defining the technology too early, or worse, allowing companies to define the technology in a collusive way without sufficient expertise from government on behalf of the potential purchaser, leads to wrong decisions.
The only solution to this dilemma is a clear separation between stages with different goals, funding schemes and governance, keeping users involved since the early stages, and maintaining options open as long as possible.

This idea is at the basis of the Lead Market Initiative (LMI) recently launched by the Commission, but still has to be strengthened and generalized[58].

Key features of the six lead market areas identified in the LMI are:

- They are highly innovative
- The aim is not "to pick winners", nor to artificially create a market for a given technology or pre-empt the development of other competing options. Therefore, the lead market areas are quite broad. They are not dependent on or focusing on a single product or single technology. These markets already have a strong technology and industry base in Europe.
- The assessment of the market potential and of the demand side (including of users' needs) is a crucial point. The market potential of these markets, both inside and outside the EU, will be largely demand-driven, while less technology-pushed.
- The six market segments provide solutions of broader strategic, societal, environmental and economic challenges.
- The growth of these market areas depends, more than other markets, on the creation of favourable framework conditions through public policy actions.

Lead markets are a subset of markets that can be created through the solution to societal challenges. As such, they offer a promising start to addressing the overall challenge. At the same time, the LMI typically does *not* allocate additional resources but mainly uses soft policy tools, such as inter-governmental coordination, standard setting and regulatory reviews, and has a supply-side orientation. The idea here is to place societal challenges firmly within the budget allocations of national and European programmes for research, as well as of Structural Funds.

The problem we address here is how to generalize this approach by linking in a more systematic way the research activity carried out under the European Commission responsibility, using its various tools, and the innovation and diffusion activities, and ideally to couple this with the larger resources available at national level. This will require:

- a stronger governance within the European Union
- a clear articulation of relative roles and responsibilities of the Commission and of Member States along the implementation path
- an innovative use of Structural Funds
- strong buy-in from research and innovation actors.

In Appendix 2.1, we provide a general framework as illustration and propose a specific way of how this could be implemented into the current institutional framework of the European Commission and of the Member States, based on a Stage-Gate policy model.

2.6 The new role of public procurement

The role of Societal Challenge as strategic priorities for EU research policy fits nicely with the recent focus on innovation policy on the role of public procurement. In recent years this theme has

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[58] The lead market area's webpage http://ec.europa.eu/enterprise/leadmarket/leadmarket.htm gives a detailed description of the market area. The Commission Staff Working Document COM (2007) 860 final SEC (2007) 1729 presents the methodology used for the identification of the markets.

gained recognition at EU level and in some Member States, with a number of promising experiences already reported (Edler and Georghiou, 2007).

To start with, in 2003 the Research Investment Plan included public procurement for innovation as an element to contribute to the 3 % Barcelona target. Then the theme was mentioned in several prominent policy documents, such as the Kok Report on the Lisbon strategy in 2004, the mid-term review of the Lisbon strategy in 2005 and the Report of the Aho Group in 2006. Thus in a few years the issue gained top level recognition and policy attention.

In parallel, both DG Enterprise and DG Research commissioned studies on various dimensions of procurement (Edler et al, 2005; Wilkinson et al., 2005), followed by various initiatives, such as PRO INNO, INNOVA STEPPIN, and the Open Method of Coordination PTP project (OMC-PTP, 2009). The above mentioned Lead market initiative (LMI) is another key element of a renewed interest, as well as the intense preparatory work carried out by the DG Enterprise with governments and procurement agencies.

This effort culminated in December 2007 with the publication of the Communication *Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe* (European Commission, 2007a). This highly innovative document and the related Commission Staff Working Document (European Commission, 2007b) articulate a framework by which the procurement of innovative solutions can be made attractive for private companies, while at the same time be compatible with regulation of State aid and competition policy. Pre-commercial procurement is defined as "procurement of R&D services that involves risk-benefit sharing at market conditions and in which a number of companies develop in competition new solutions for mid- to long-term public sector needs. The needs are so technologically demanding and in advance of what the market can offer that either no commercially stable solution exists yet, or existing solutions exhibit shortcomings which require new R&D. By allocating R&D benefits and risks between public purchasers and companies in such a way as to encourage wide commercialisation and take-up of R&D results, more beneficial time to market conditions are created allowing both the public sector to introduce innovations faster and industry to be the first to exploit new lead markets."

By using pre-commercial procurement it would be possible for governments to buy new solutions without being stuck in the dilemma between buying far-from-market R&D services and distorting competition, by exploiting the exception of article 16f of the Directive 2004/18/EC on public procurement.

As the OMC-PRP Report makes clear, in fact, "Pre-commercial procurement will normally be organised in a way that is different from a regular procurement. The underlying reason is that in pre-commercial procurement there is still a technology risk due to the development effort required before an innovation can be made commercially available. This also implies that pre-commercial procurement includes the need for a strong interaction between the demand and the supply side, this interaction seems stronger than is needed within the standard commercial procurement procedures. The main characteristic of innovation/technology is the potential it creates to improve operations and productivity and the functionality it offers to solve problems that are out of reach of existing traditional technology. Against the upside potential there is a downside risk for technical failure when spending money in developing (supply side) and acquiring (demand side) innovative products/services." (OMC-PTP, 2009, p. 53).
After pre-commercial procurement standard rules for public procurement may apply. At this stage, however, lot of uncertainty has been reduced, all actors are more informed, and expectations on the rate of return to investment will be more realistic.

It is important to note that the European Parliament has endorsed the Communication, with a Resolution dated February 3 whose text is particularly strong and encouraging. The Parliament "considers that pre-commercial procurement constitutes an under-exploited driver of innovation-led growth for the EU with significant potential to achieve high-quality and readily accessible public services for example healthcare and transport, as well as to address the social challenges of climate change, sustainable energy and an ageing population", and "regrets that many public authorities are not aware of the potential of pre-commercial procurement and do not yet act as "intelligent customers" (European Parliament, 2009).

A careful combination between research programmes, innovation and framework conditions policies, and pre-commercial procurement on the part of national and regional governments, might indeed create a strong platform for addressing Societal Challenges.

2.7 Conclusions: structuring a policy response to Societal Challenges

Based on a shared European vision and consensus, what does one want to achieve? Not really inventing a new helicopter or any kind of pre-defined technology that does not yet exist. The goal is rather, and limiting ourselves here to the ideal case of a Societal Challenge to promote a large area of "climate change – ameliorating innovations (health - or water supply - or nutrition -)" *where the EU can develop a comparative advantage*. The problem as argued above, is not so much one of selecting the right technology, but making such activities (like "climate change ameliorating innovations") as profitable as possible so that competitive entry (entrepreneurships) and intrapreneurial activities will occur, and this is central to mainstream research planning and innovation policy. A main goal therefore is to increase the rate of return on R&D in the particular fields through a concerted set of actions in order to generate positive responses from the private sector.

In what sense is a policy addressing a Societal Challenge different from a classic policy that is designed to address chronic underinvestment in R&D on decentralized markets? In the latter class of policy, the main goal is to increase the rate of technical change while in the former the goal is to influence both the rate *and the direction* of technical changes.[59] This is what makes the designing of such kind of policy difficult and… a "grand" challenge.

As argued in this Chapter, some good documentation about federal US policies which were successful in preparing (and advancing knowledge toward) the Internet revolution is illustrative here (Blumenthal, 1998; Mowery and Simcoe, 2002; Mowery, 2006; 2007). Such policies involved a set of concerted and (loosely) coordinated actions on both the supply and the demand side of a broadly predefined agenda:

- to create and expand the required "knowledge infrastructure" (human capital, science, technology and engineering capabilities);
- to induce the private sector to respond positively to government policy by making the new domain as attractive as possible to for-profit organizations;
- to encourage the creation of a market for the new technologies through public procurement and adoption policies.

When analyzing the reasons for the success of the Internet revolution in the US, many experts frequently overlook decades of federal expenditures through DoD and other agencies to develop the knowledge infrastructure and human capital. A central component of any response to a Societal

[59] To borrow the title of the famous NBER 1962 book offering many seminal contributions in our field.

Challenge is therefore building the fundamental capacity to perform research in the future and ensure the mobility and use of the knowledge and skills that are created. This includes steps to promote the training of scientists and engineers, to rejuvenate laboratory capabilities in universities and other PROs, to establish programmes to disseminate research information for example through internships, postdoctoral fellowships and exchange programmes, both intra-European and between Europe and the rest of the world, and to foster the development of environments that promote the concentration of so-called "related variety"[60].

The generation of an adequate supply of knowledge, ideas and instruments as well as highly skilled people and receptive environments for collaboration and problem-solving activities constitutes a central pillar of any structured response to a Societal Challenge. Even a generous programme of R&D subsidies offered to private companies will fail to produce more innovation and faster growth if the knowledge infrastructure fails to provide an adequate supply of the various knowledge assets and adequate competition. Without an abundant supply of basic knowledge, human capital and academic and inter-corporate collaborations, private investors in this area are at risk.

Government R&D policy should also encourage more risk-taking and tolerate failures that could provide valuable information. This can be accomplished by adopting parallel project funding and management strategies and by shifting the mix of R&D investment towards more exploratory R&D that is characterized by greater uncertainty in the distribution of project payoffs.

Not only is the promotion of scientific capabilities important, but also the development of engineering capabilities: the willingness of private industry to commit financial resources to scientific research is considerably increased by the progress of the appropriate engineering disciplines. Strong engineering capabilities are also a mechanism to ensure that endogeneity kicks in, i.e. to make universities and public RTOs fully responsive to the technological and scientific needs of industry in the Societal Challenge related areas of R&D.

Public policies supporting innovations have proven especially effective when funding for R&D was combined with complementary policies supporting the adoption of innovation. As noted in a recent paper by Mowery (2009), the presence or absence of complementary procurement policies is an important factor mediating the economic effects of strategic/mission-oriented programmes. Many of the widely cited "spin-off" benefits of post-war US defence-related R&D spending have as much to do with the scale and structure of the procurement programmes that accompanied them as with the structure of the R&D programmes themselves. The lack of such procurement programmes in other mission areas, such as energy (because of the lack of federal responsibility), has arguably reduced the effectiveness of US mission-oriented R&D programmes in the field. (It will therefore be important to ensure that the steps taken in Europe to liberalise the energy market do not similarly hamper implementation.)

In the area of climate change, the improvement in the energy efficiency of public sector building and transport systems is a good example of an important area of R&D investment that can generate near-term business innovation and private expenditures if the market for application is initially subsidized by public policy measures (David, 2009).

In fact, analysis demonstrates that there are many climate-related initiatives that are potentially of low or negative cost, which nonetheless fail to be addressed under the constraints of current market structures and policies. Any R&D policy designed to address one of the global crises of our time (climate, energy, water, food, etc.) must activate a variety of instruments and mechanisms to create the needed knowledge infrastructure (human capital, science and engineering capabilities),

[60] Hence the link with the proposed ERA reforms, see Chapter 2.

encourage private sector expenditures through various kinds of incentives and demand-side initiatives and develop an EU comparative advantage in certain innovation areas (dealing with the problem).

To conclude, there is certainly a conflict between *the classic desirability of maintaining neutrality* in technological choices in order to mitigate the usual distortions created by the provision of subsidies to favoured firms and industries and *the need to influence not only the rate but also the direction of technical change*. One of the messages of the EG is that this conflict can be considerably diminished when each of these two needs is applied at the proper level of aggregation. Structuring a policy response to a Societal Challenge effectively and efficiently requires a fine policy mix, involving non- neutrality at the very general level of the identification of the challenge (to build a broad political consensus) and neutrality at the more specific level of the selection of R&D priorities and technologies within the large scope of operation defined by the Societal Challenge (to leave the market free to experiment and select). There is no logical necessity in the idea that government failure is always larger than market failure.

The second message is that such a policy response to a Societal Challenge can prove valuable in three ways:

- by rapidly addressing some of the great socio-economic and global problems;
- by playing a contra-cyclical role during the current recession; and
- finally by providing a new political support framework for European policy initiative pulling together and coordinating national policies in each of the 27 member states.

Appendix 2.1 Implementing a Stage-Gate [61] policy model for Societal Challenges[62]

A2.1 General framework

The general idea is one of designing a new balance between flexibility and commitment.

On the flexibility side, there is the idea of allowing entrants to come up with the best ideas, in an adaptive/evolutionary fashion, basically a dynamic and competitive market-based process. Furthermore and still on the flexibility side, there is also the idea of being able to stop projects that become negative net-present-value projects, i.e. to avoid the so-called 'soft budget constraint' syndrome. At the same time, one must come up with a solution to avoid under-investment from companies, or short-termism, if they anticipate the possibility that projects will be stopped, perhaps arbitrarily, before commercialisation is possible.

A Stage-Gate model is a technique in which a (product, process, system) development process is divided into stages separated by gates. At each gate, the continuation of the development process is decided by (typically) a manager or a steering committee. The decision is based on the information available at the time, including e.g. business case, risk analysis, availability of necessary resources (money, people with correct competencies), etc.

Without any attempt to impose a specific label, let us define the general stages of such a design as follows:

(a) Exploration stage;
(b) Finalisation stage;
(c) Application stage.

a) In the Exploration stage, new and radical ideas for how to address Societal challenges should be encouraged. There must be competition among all actors (public research, industry) and the results funded by European research money must be open and fully accessible. Exploration of all possible alternatives should be fostered, with no reverence to the established technologies or company positions, and sufficient public support for foresight exercises, scenario planning and technological road mapping. Data must be publicly available, so that they can be used for further replication, validation and diffusion. In this stage there is no need to force cooperative research. It should be possible for single research units or firms to submit a proposal. Research money should be quite limited, because there will be no large scale experimentation and testing.

However, it is important to involve final users into early conceptual innovation experiments in this stage. New methods should be implemented, such as Functional Analysis for the generation of radically new ideas and Ethnographic observation for early detection of user issues.

This activity must produce a clear Proof-of-Concept demonstration.

At the end of the Exploration stage there should be a preliminary Technology Assessment gate. All options should be subject to independent evaluation and strengths and weaknesses should be clearly elucidated. Results of the Assessment should be public. The Technology Assessment should be done through peer review, even open peer review, and not delegated by a committee that does not take final responsibility on the final advice.

[61] The term Stage-Gate® is a registered trademark of the Product Development Institute.
[62] This appendix is added as illustration of the principles which the EG considers essential when designing an appropriate policy model. It does not address the many technical details.

The Technology Assessment exercise would be a gate, in the sense of suggesting the go/kill decision for the next stage. However, taking into account the probability of mistake, a small percentage of killed ideas (say 20%) should be permitted to resubmit.

b) In the Finalisation stage, the formation of consortia or coalitions of actors should be encouraged. Actors would bring complementary technologies and would build complete system architectures of new solutions to Societal Challenges.

Since the results of Stage 1 research are public, there would be a great opportunity for all participants to access the best available knowledge. However, at this stage there must still be strong competition. Several architectures must compete fiercely. It is not enough to have variety in the early conceptual stage, there is a need to have parallel exploration of all systemic problems down to the details of use of systems[63]. Therefore we should have several consortia, competing against each other to demonstrate the virtues of their systemic solutions. At this stage consortia may impose severe IPR restrictions. However, the EC should insist that all data referring to experimentation and testing should be made available, in order to avoid monopoly positions. Information on drawings and technical details, on the contrary, might be proprietary and protected.

The Finalisation stage should include an extensive Field testing activity. Early users involved in the conceptual stage are not enough here. The Field testing stage should include Public Administrations, municipalities, local utilities, consumer associations, voluntary organizations, and the like in large scale social experimentation of the adoption of new technologies.

All consortia should carry out these testing activities according to the same protocol.
Furthermore, all consortia should provide certifications (CE) and quality standard compliances needed to operate in the market. No further substantial uncertainty should be left on the shoulders of the prospective buyers of these solutions.

At the end of the Finalisation stage a final Technology Assessment exercise should be carried out. Again, the results should be made public. The Assessment will illustrate the benefits for society of all options, as well as the costs and risks associated.

c) For the Application stage we have a simple suggestion: use Public Procurement. National and regional Governments should take a commitment to buy those solutions that emerge positively from the second stage Technology Assessment. This commitment should be taken *before* the completion of stage 2 (Finalisation), in order to give an incentive to all actors in competition to deliver better results.

The EC should fund the Exploration and the Finalisation stage, *but not* the final Application stage. Systems must be ready to deliver their value in the final stage, so they should be ready for public procurement. Governments might adopt the specifications that come out from the Finalisation stage as the basis for their tenders. Those companies that received the best Assessment will have an advantage, because they have more experience with these specifications. However, it will also be possible for other companies to converge on the winning solution.

Under certain circumstances, governments may also ask the winners of stage 2 to share their technology, perhaps under licensing agreements, in order to enlarge the market.

[63] Interestingly, this is the approach followed by the US Small Business Administration in managing the SBIR scheme for R&D in small firms, apparently with great success.

We insist on the importance of public procurement at regional level. It will be easier for 3-4 regions across Europe, irrespective of their national policies, to agree on a common procurement policy. While national governments are committed to protect national companies, and might be reluctant to abandon their champions in favour of technologies developed abroad, regional governments may have more degrees of freedom. In areas such as environmental protection, health care, aged people, energy or mobility, regional governments have concurrent or exclusive legislation in many European countries. Regional public procurement is the next stage for demand-driven innovation policies.

Simply committing governments on public procurement will have an enormous incentive value for companies. Their systems must perform appropriately, since there will be a though customer at the end. It will not be possible to develop prototype-type results, as it is still common in most technological research with European money.

However, governments can make a commitment to procure new technologies only if they are proved. There must be a tremendous effort to deliver ready-to-use systems, although adaptations will always be required. A full Life Cycle Management approach must be demonstrated.

The Stage-Gate approach we suggest has several advantages:

- it permits a reduction of uncertainty over time, both in technology and use conditions;
- it allows continuous feedback from users, from early involvement in the Exploration stage to large scale field testing in the Finalisation stage, using most advanced techniques;
- it gives incentives to researchers to explore wildly different solutions, in the hope their ideas will be picked up in further stages;
- it gives incentives to companies to produce the best solutions, in the hope their products and services will be procured by governments;
- it gives incentives to procure new technologies safely, because all experimentation and field testing activities have been carried out;
- it does not offer any excuse for relaxed type of behaviour (i.e. developing unusable technology in the hope there will never be a “real” customer, and circumventing bureaucratic requirements);
- it addresses rationally the issues of information asymmetry and technological uncertainty;
- it demands the Commission to concentrate financial resources in the upper stages, leaving the lower stage to governments, thus leveraging on scarce financial resources;
- it leaves open the possibility of Art. 169 cooperation among countries, even without the involvement of all Member states, thus taking into considerations the differences in the need for public procurement across countries;
- if public procurement projects have sufficient scale, it allows the formation of large markets, with adequate critical mass, that become attractive for private investors in the long term.

It clearly requires a great deal of contractual and administrative innovation, as articulated below.

A2.2 New policy approach and tools

Alongside the Stage-Gate policy model, new tools for societal involvement must be explored. New participative and networking methods are increasingly used for these purposes, including groupware for supporting face-to-face interaction in scenario workshops, content analysis, mindmapping, and deliberative democracy tools. However, several authors note that “one problem in the foresight process lies in the tension between human stakeholders (the participative dimension) and technical expertise (employed in prospective studies and some planning tools). The issue is that increasingly sophisticated methodologies of futures analysis and planning may be hard to integrate with more participative activities” (Miles et al., 2008, p. 408).

The point is that simply “asking society” is not adequate. When asked, society does not tell you what you need to drive policies. There is often a naïf argument in recent debates, according to which consultative, open, bottom up methods of society involvement into technology policy making are *the* solution. There is still a gulf between what society asks, and what should be done in technology and innovation policy making. Society is neither like military complex, nor like professional users.

According to many authors, but also to authoritative policy fora (e.g. the European Commission Expert Group on Policy Mixes[64]) there is strong need for developing new policy tools at the interface between deliberative procedures aimed at involving users, stakeholders and citizens, and the technical expertise needed to make appropriate decisions in technology policy.

However, new tools should be developed in order to manage the complexity of technological development alongside the complexity of social demand. A promising line of inquiry comes from Functional Analysis, a rigorous tradition of scientific analysis of engineering design, the cornerstone of any technological progress[65].

In short, with this proposal we have put forward a series of requisites for policy making in demand-driven innovation policies:
- keeping exploration of technological options open until possible
- avoid regulatory capture from incumbent companies
- involve final users and stakeholders early in examination of technological options
- keep flexible until the cost of delaying adoption becomes larger than the benefit from further exploration and learning
- take into consideration network externality effects, taking a commitment to a technology only when it can be considered credible by final users.

A2.3 A realistic governance for Societal Challenges[66]

These ideas must find a realistic way into the current institutional framework and the policy toolbox. Otherwise, they will not be robust to implementation issues. Let us first review some risks of proposing a Stage-Gate approach, which come from a number of still unsolved issues:

- Policy makers have followed, in the last two decades, an approach based on separating policy planning from delivery, delegating it to market-based mechanisms. In turn, this typically make policies rigid, because policy makers are detached from implementation issues and do not really adapt policies to the limitations that emerge from practice;
- Rules for sharing responsibilities and profits between public and private actors are not yet clear and stable (as the experience of Galileo has shown);

[64] See www.policymixes.eu.
[65] See the large number of papers on functional analysis and its application to foresight and social issues submitted to the last International Conference on Engineering Design (ICED), www.iced2009.stanford.edu.
[66] To increase the degree of realism, the Stage-Gate policy tool box as well as the way it should be implemented has been described at a rather high level of practical detail. This is just meant as an illustration of the way the ground principles suggested here, could be implemented by the EC.

- If we separate the responsibility for research from responsibility of governments in public procurement, it is difficult to ensure coordination, so that the classical situation of research that "never finds a real customer" is perpetuated, not removed;
- If we allocate responsibility for procurement to national governments, they will inevitably prefer national champions;
- If the time window between research and final implementation is too long, it will be difficult to mobilize research communities, to align their goals to public priorities, and to avoid serious management issues;
- There is already a "jungle of programmes" at European level, so the introduction of new schemes is dangerous.

From these initial remarks, it becomes clear that the overall governance of Societal challenges is a crucial issue. The governance should be simple and authoritative, but at the same time it must permit the management of complex issues.

From the point of view of European Commission role, we warmly recommend strong coordination and shared vision and responsibilities between all the DGs involved. Although such coordination is the crux of innovation policy almost everywhere, and we do not ignore the intrinsic associated difficulties, it is highly recommended that a new approach is put in place.

The issue of "how" of societal challenges-led research and innovation policy is the crucial one. Nobody has the final answer to the question how to design and implement an appropriate institutional framework. The difficulties experienced by all attempts, discussed in this Chapter, witness how difficult is the issue. Therefore we do not advocate a single institutional and governance design, but leave the options open for deep reflection at policy level. We can consider three main options:

(a) inter-directorate governance, high political profile, and platform management
(b) coordination based on conditionality and variable geometry
(c) executive agency

Inter-directorate governance, high political profile, and platform management

This option sees societal challenges as a major theme for the Innovation Plan and demands that all Member States take a high profile role.

A societal challenge approach applies a much stronger coordination across the policies and programmes that could support the achievement of the objectives. Moreover, the societal challenge approach should lead to stronger focus and greater coherence in the range of projects, policies and tools selected, as well as simplified engagement for innovation actors who would be involved in a single set of relevant actions rather than a fragmentation of initiatives across programmes, policies and DG's.

Based on experience to date, a new approach could be introduced in the Innovation Plan with the following features.

High level political governance
A small number (e.g. 2 – 4) Societal Challenges are identified for a coordinated, EU level response. These should be clearly linked to the future Lisbon strategy and selected in terms of the innovation potential, EU added value, and importance/ medium term nature of the challenge. The final selection of the challenges should be a high level political decision, i.e. by the European Council who would also take other major decisions.

The definition of the challenge should be of a sufficiently high level to warrant a EU level coordinated response but sufficiently targeted so that clear goals can be set and that agenda setting and implementation is manageable.

A smart package of policies and actions
For each challenge a coordinated set of actions should be agreed which make use of the full range of relevant tools and competences within the control of the public sector.

At EU level, the toolkit could include: calls under the thematic priorities of FP; innovation actions under the Competitiveness and Innovation Programme; instruments of the Lead Market Initiative; and instruments under the European Research Area, such as joint programming. Consideration could also be given to including further policy tools, such as: the market monitoring exercise under the Single Market; Financial instruments (equity, loans etc) and/ or training and education programmes with a thematic basis.

At Member State level (including regional and local levels), the toolkit could include research programmes, innovation programmes, public procurements, testing/ demonstration within public services, infrastructure and planning, etc. Under the societal challenge, the relevant ministries should be engaged to align, coordinate or jointly implement policies and actions. This could also involve actions financed by the Structural Fund programmes.

A partnership approach
A platform could be created for each of the identified challenges to develop and agree an action plan and ensure coordinated implementation. The platform would bring together the key partners, in particular those responsible for the policy tools from Member State ministries, agencies and regional/ local bodies and from Commission services. The platform should also engage businesses including SMEs, non-governmental organisations, and leading researchers and experts. This could make use of existing structures such as European Technology Platforms.

A champion for change
For each challenge, a champion could be appointed as a high level, experienced leader supported by a small secretariat. The role of the champion would be to act as a change agent, to drive the process and to report on progress. An innovative approach could also be taken for the secretariat, for example by using seconded staff with relevant experience drawn from the Commission services, Member State administrations and external experts.

Coordination based on conditionality and variable geometry

This option takes seriously into account the possibility of policy failure and bureaucratic capture. Therefore it advocates a stronger definition of contractual schemes that reduce the risk of “soft budget constraints” (i.e. to fund projects beyond the point where their usefulness is clearly remote) and also does not demand that all Member States participate to political decisions.

This scheme uses then the legal notion of variable geometry in order to induce a differentiated approach by Member States, making decisions more fluid.

These levels of governance will be responsible for the following activities.

A. Exploratory stage

The Exploratory stage is mostly funded by DG Research. DG Research, within the limits of FP 7 and in future FPs, may use a wave of calls to mobilise the research community towards a small number of Societal Challenges.

This does not take necessarily the form of new research projects, since most of them will already be in place within IPs, STREPs or JTI. In areas where there is a gap, new projects may be at the basis of the Call.

The Exploratory stage exploits existing research activities, but also opens new Calls in areas not covered by the FP, if needed, or covered in a different perspective. In this case, it adds money in order to support exploratory research on alternatives for addressing Finalization and Application issues for the delivery of Societal challenges.

It takes the form of a Call for Finalization candidatures whose goal is to identify possible leaders for the subsequent stage. Candidatures must be associated to a clear plan on how to lead and implement a Finalization activity, based on research results and a clear understanding of final application challenges.

Candidatures must include a Risk management plan and a clear management structure. The relation between research results and the proposed Finalization must be explicit.

In the future, EIT KICs may present a candidature as such, realizing a ready-to-use critical mass of research and users. KICs seem natural candidate, if successful, to implement demand-driven innovation policies.

B. Finalization stage

After the launch of the Exploration stage, Finalization projects must be ready to start. Their duration should be limited in time and not exceed, say 24 months. At the end of the period, there must already be a wave of procurement practices for new solutions to Societal Challenges, based on the specifications issued by Finalization projects.

For each dossier of Societal Challenges, there must be at least two Finalization projects in competition. The leader typically should not be a research institution, although all projects must have substantial input from research and include research clearly in the management structure. Finalization projects are based on public-private partnership. Their legal nature may be variable.

C. Application stage

In parallel to the Exploratory stage, the EC would open a consultation procedure with Member States and with Regions.

The goal of the consultation would be:

- to set up art. 169 reinforced cooperation agreements among Member States, or agreements among Regions, aimed at sharing responsibilities for future decisions on public procurement in selected areas;
- to delegate a political committee formed by participating national and regional governments, staffed by an adequate technical support from administrations, in charge of cooperating with Finalization projects in defining the specifications of future tenders for public procurement;

- to ensure that participating countries and regions will collaborate in launching large scale testing exercises of Finalization solutions in the respective fields;
- to set up a legal advisory board, in charge of identifying the legal and administrative path that the Finalisation solutions may safely follow in order to facilitate the implementation in member states and regions.

Agreements must be signed and put in operation before a predefined date. Once signed the agreements, Member states and Regions have access to the Finalization programmes, and will actively intervene in the definition of specifications, to be used in future procurement procedures.

It would be great if a strategic agreement with DG Regio could be achieved, with the following content:

- DG Regio should consider Societal Challenges as a key component of conditionality (see also the analysis and proposals made in Chapter 5;
- DG Regio could e.g. announce that future allocations of Structural Funds to Member states will include a significant attention to Innovative procurement;
- From a practical point of view, monies could be allocated conditional to the political willingness of Member states and Regions to adopt public procurement schemes, and co-funds such schemes considering them as an investment activity (whatever the content in terms of products/services actually bought);
- DG Regio should participate in Finalization projects.

Executive agency

Another option would be to strengthen the coordination up to the point where a separate institutional, legal and administrative entity is required – i.e. a public agency. One may think for example at a European Agency for Climate Change. It must have a larger autonomy than the EC has so far granted to other independent bodies, such as ERC or EIIT.

In favour of this option stands the historical experience. Most examples of successful demand-driven innovation policies have seen the involvement of large national agencies, or of similar entities with large autonomy and strong technological and scientific background. The problem here is of course the willingness of national governments to delegate powers in fields that still are largely controlled by national authorities. But the alternative might simply be no additional money on these issues. Agencies benefit from attractive labour conditions for skilled technicians and researchers, as well for managers and administrators willing to be involved in the implementation stage. In political terms, it could be argued that governments and the public opinion would buy the idea of an additional agency in charge of addressing, with a clear mandate and a tight time schedule, a number of complex societal issues. Setting up an agency will in any case require a number of years.

Chapter 3:
Public research in Europe

3.1 Introduction

This Chapter considers key roles of public investment in research and development. In the following funding issues, governance, quality, excellence, specialisation and knowledge transfer are considered for this part of the research and innovation system. In exploring the role of community research policy in the knowledge based economy, the research organisation and the funding of universities and Research and Technology Organisations (RTOs)[67] as well as research carried out by industrial enterprises and services, is essential.

Public research in Europe is carried out predominantly by universities and RTOs. Both kinds of institutions operate under diverse legal status, structures and in diverse funding modes. The European Association of RTOs (EARTO) defines RTOs: *Research and Technology Organizations (RTOs) are specialized knowledge organizations dedicated to the development and transfer of science and technology to the benefit of the economy and society*[68]. RTOs therefore occupy the middle ground between academic research and practical application. In the context of this report, we use the term RTO to include all non-profit research organizations that are not universities (excluding the Research Funding Organizations). Therefore, our use of the term RTO covers those that are closer to Academia and those that are closer to the market as well.

Due to historical circumstances, universities are managed differently in different European countries. Some countries have a central system for tertiary education while others have totally or partially devolved the system to regional governments. This complex institutional structure often makes reforms difficult to implement. In addition, the reform difficulties are compounded by political differences and internal tensions within the universities themselves between those which seek to preserve the idea of 'academic freedom' and those which push for wider engagement with industry and society. Although a general trend can be observed in granting universities greater autonomy from government, legislation which should enable this remains highly uneven across Europe and so does the actual use of newly acquired "autonomy".

Universities are in a general sense subject to great hopes for showing how they can contribute to the knowledge economy. New expectations and pressures for change are on the rise. Some pressures emanate from students becoming more mobile and demanding, accompanied by the development of an international market for higher education. The current shortage of public funding, rapidly changing needs in industry and the service sector and increasing requirements of lifelong learning and learning in the work place create additional pressures on universities to respond. Pressure for change has also been stepped up considerably through the introduction of (some) measure of competition among universities, notably through the introduction of systems for quality assessment and quality control. The rapid diffusion of bench-marking systems and the dependence of funding on evaluation of research and higher education performance indicators have added considerably to pressures for change in the European university landscape.

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[67] By using the term in a broad sense, we emphasize their mission of knowledge production and transfer which positions them somewhere between the pole of 'research' and the 'innovation' pole in the so called Knowledge Triangle.
[68] http://www.earto.org/

When one compares data on investments in European and US universities substantive issues regarding the comparability of data must be taken into consideration. However, it is clear that the overall amount spent in the US in higher education is much higher (1.3% of GDP in the EU versus 3.3% in the US) if one takes into account public and private investment (see Chapter 1, section 1.6). This necessarily has effects regardless of whether funding is spent directly on research or in sustaining other funding needs of universities.

In addition, the aggregate differences in resource provision to universities and RTOs between EU and US mask a considerable variation, which impacts what applies for the individual institution. The US has a highly stratified system that displays huge discrepancies between universities, as they range from those with the greatest resources among any of the world, to a large number of underfunded institutions. At the same time, US universities display greater diversity when it comes to access to different sources of funding, compared to the EU, where public funding is much more dominant. Another structural difference in the organisation of higher education is that the EU has more universities granting Ph.D. degrees (which in turn grant a greater number of such degrees) than the US, where a greater share of institutions focus on undergraduate studies. These structural differences result in the US having a relatively small number (approximately one hundred) of top universities focusing primarily on research. In Europe, by contrast, most universities seek to combine the function of mass education at undergraduate and even graduate level with research, which prevents them from competing fully on research quality and impact.

RTOs account for about 40% of publicly funded R&D and about 14 % of all R&D in the EU-15 (EURAB, 2005). Their weight varies considerably between the individual member countries. However, according to the EURAB report RTOs account for 15%-30% of total expenditure in Portugal, France or Spain with a substantial lower share in Sweden or Belgium (less than 5%). Differences in the relative importance of RTOs generate different pressures for change. Although many of the issues confronting them are of a generic nature, different policy approaches may be required to tackle them, both in different countries and at European level.

Clearly, the heterogeneity of RTOs, with differing missions and diverse integration in the national systems, is even greater than that of universities. While having undergone some major shifts towards Europeanization and internationalisation in the last decades, RTOs continue to operate mainly as national entities and hence under the competence and legislation of Member States. As a consequence of the government subsidies and often their focus in the “home market” RTOs suffer from a national lock-in, despite their contribution to international research programmes.

While universities combine teaching and research, RTOs are as a rule not engaged in teaching. Although many RTOs train PhD and post-docs, only a few (like some of the Academies) are able to award PhDs and teaching is really an exception for RTOs. Being more “mission oriented” and in general less influenced by academic tradition, the RTOs are generally more manageable. Many RTOs are also far better prepared than universities to work with the private sector. RTOs clearly play an important role in certain industries, services and countries, whenever their management is professional and where they contribute to industry renewal.

It is noticeable that many RTOs tend to be more aligned with, and are closer to, existing industry/services, compared to universities. Their research agenda may, however, also show greater overlap with universities and be less complementary to industry. On the other hand, universities may be less inclined to become trapped by vested industrial interests, and may thus breed research and innovations (including general purpose technologies) that are more relevant to a range of industries and services, including emerging ones. In addition, the links that typically exist at universities between research and higher education offer a number of advantages for industry, especially through the extent to which graduates employed by industry have acquired valuable, as well as fungible skills. In overall, the issue is not whether universities brand RTOs can perform better each other's functions in relation to industry, but how they complement each other.

A specific case to be mentioned is the one of RTOs dealing with Research Infrastructures, which represent special RTOs performing mainly basic research services. Since several years they tend to organise themselves to serve better the research community at European and international level[69]. The links that exist with universities and the basic research they support allow them to train a high number of Ph.D. students and young post-doc researchers.

Many of the issues discussed specifically for universities are applicable to RTOs as well. While it is more straightforward to urge reinforced public-private partnerships for RTOs, there exist also plenty of unfulfilled and potentially favourable opportunities for RTOs to collaborate more closely with universities. The concrete form under which specialisation and collaboration might be developed needs to be worked out based on an understanding of the specific strengths and opportunities that pertain to each institution. An interesting case is provided by the Forschungszentrum Karlsruhe that recently merged with the University Karlsruhe in the wake of the German Excellence Initiative. It now has been established as the Karlsruhe Institute of Technology, KIT.

3.2 Governance of universities

Too often the current Higher Education governance systems across EU do not allow for specialization and diversity. Legal and policy frameworks should allow for greater autonomy and for universities to develop their own strategies provided that criteria of quality and relevance are met. In addition, there is a need for fostering capabilities in university management in support of specialisation and diversity in the wider knowledge environment, while boosting creativity and initiative from below (Andersson, 2008). If universities are to remain the prime knowledge producers, and facilitate innovation that has potential to generate what is truly new, universities must be able to test and improve their own way of governance, based on striving to cherish the strengths and opportunities that pertain to the specific institution. Today, the ability of universities to do just that is, in practice, restricted due to a combination of funding principles and governance structures which hinder autonomy, excellence and social relevance, often also in need of professionalization.

Policies should be framed in recognition of the need for multiple and inherently diverse and complementary institutions engaged in higher education, research and innovation. Each university must then be able to foster its own specific governance model, capable of serving as an instrument for day-to-day learning as well as for setting long-term strategies. This must apply across the range of university functions, including education, research, innovation with the wider society. This calls for greater quality and diversification also in accreditation, evaluation and ranking of universities.

As stated above, specific policies are needed for pluralism and complementarity to develop. A general observation however is that greater strive is needed to reform and improve the governance of universities. Emphasis on strategic work, active examination of lessons from best practices and abilities to implement needed reforms must be viewed as long overdue in most universities in many European countries. Although incentives and requirements for reform have been initiated in recent years, putting in place policies capable of engineering more effective implementation of the lessons learned, by central and regional governments as well as by universities themselves, is a matter of

[69] As an example, European Strategy Forum on Research Infrastructures (ESFRI) was created in 2002.

great urgency. Part of the answer in this regard lies with awarding universities greater autonomy. Despite some deregulation in many countries, legal structures still tend to severely limit the autonomy of universities, including their financial room for manoeuvring, in the selection of students, the recruitment and compensation of professors, and so on. Thus, in order to raise the quality of higher education and to excel in research, the barriers against such efforts must be addressed and removed. At the same time, one must be aware that the autonomy of universities is not a panacea to overcome the extremely conservative attitudes in terms of resistance to change that prevail in many institutions. Autonomy is necessary but not sufficient condition for change.

It is the view of the group that each university must define and implement its own strategic profile. Differentiation is inevitable and can evolve in many directions. Students must be able to select what suits their needs and aspirations best and universities must be able to select students according to the strategic profile. Universities also need to meet with various options how to define their core mission and develop unique combinations of higher education, research and other relations and outputs of relevance to society, as laid out in the concept of the Knowledge Triangle.

3.3 Differentiation of universities

Since most European universities are based on the legal fiction of equality of degrees, differentiation according to profile is clearly underdeveloped. In other words, universities tend to unequivocally aspire to be able to combine research and teaching in a universal, Humboldtian spirit within the same institution and regardless of its size, instead of sharpening their own, unique profile. In fact, differentiation is not solely a question of "overall quality" but also of "focus". Specifically, one should not concentrate exclusively on research excellence, accompanied by heavy concentration of funding and talent, strong selection of students and (international) university staff. Indeed, every researcher cannot belong to a "research elite". Success can also come from a well-positioned profile that each university and its constituents can define for itself, in terms of its balance of teaching and research, levels of teaching, kind of research, combinations between teaching, research and relations with industry or other parts of society, and its local, regional national or international aspirations, outreach and impact.

Bonaccorsi and Daraio (2009) suggest that countries that have implemented policy instruments directed towards increased differentiation are ranked high in international university rankings. They also find that the European landscape of universities is poorly differentiated and therefore concluded that there is a structural linkage between the poor performance of European universities in research-based rankings and the lack of differentiation. The factual dominance of streamlining regulations, national funding systems and traditions further reinforce the *statement that more diversity is needed in terms of profiling universities, not less*.

The fact that many European universities operate first and foremost in a regional or national context naturally has consequences that need to be spelled out, e.g. in terms of the geographical-regional distribution, of aspirations and requests to be relevant in a local context, and of almost every university wanting to do also 'research'. There is also the issue of size: while some universities, e.g. in Southern Europe, have been so big as to be unmanageable, in other countries there is a common belief that universities have to be "big" to be competitive. In Denmark, for instance, the merger of universities has been seen as a strategic response to increase efficiency, as well as to achieve greater international visibility in global rankings[70].

[70] The reform of the Danish universities (from 2002) is currently (2009) being evaluated.

Whereas the EC has limited responsibilities with respect of universities, the European level matters and should be mobilised for furthering differentiation under "incentivizing" conditions. Europe has an interest in doing so, which should take pre-eminence over pushing for a neoliberal agenda or setting objectives for harmonising European universities according to one-dimensional objectives. The EC as well as the member countries need institutions that specialise in addressing multiple objectives, which has consequences for determining the profile of individual institutions. Excelling in research will, in some disciplines and knowledge domains, require concentration, whereas nimbleness and networking may be most efficient in other cases. Producing high-quality graduates meeting the needs of industry, public service, and the professions, will typically require a more 'professional' profile, entailing perhaps also close contact with future employers. If the main objective is to raise the numbers of young people in the age cohort to pursue tertiary education, the profile will differ again. In practice, these and other objectives will not be so easily separated, but differentiation and sharpening the profile of each university depends on obtaining clear priorities among the main objectives.

The EC has a role to play, not to harmonize the European university landscape, but to further a framework in which instruments required for multiple successful development paths are developed. This can be achieved by introducing a clear and strong, merit-based competitive scheme for universities (and RTOs) at EU-level. The EC could also set up further bench-marking exercises that would help to compare and monitor the future professionalization of universities.

3.4 Quality of research at universities

Measurement of quality of research or of the performance of institutions as well as of the impact generated by research must be carried out with utter care. Since the results are likely to be used either for comparative, bench-marking purposes or with specific policy measures to be attached, indicators should never be allowed to take on a life of their own and must always be carefully interpreted. Keeping this in mind, it is widely believed that European universities lag behind US universities when it comes to the quality and impact of research as shown by measurements of scientific output in comparing the ratios of publications with respect to population, or to the number of researchers (Dosi et al. 2006). The same exercise can be applied to researchers that have received the highest number of citations across the past two decades (see table). In this case citations have not been corrected for disciplinary structure. A more detailed disciplinary study contained in Bauwens et al. (2007) corroborates the leadership of the US.

	Number of HCRs	HCRs per million inhabitants
United States	3.829	16,82
Switzerland	103	16,28
EU (15)	1.177	3,01
UK	439	7.79
Sweden	59	7.09
Netherlands	92	6.50
Germany	240	3.12
France	155	2.88

Source: Bauwens et al. (2007) (HCR: Highly Cited Researchers)

Another aspect of universities' research performance, already mentioned in Chapter 1 (section 1.6), has been discussed by Aghion et al (2008). Using the "Shanghai ranking" of universities grouped by countries, they observe that US universities outperform European universities in the Top 50 and Top 100. European universities do better in the lower tiers (Top 200 and Top 500). Europe thus appears to lag behind the US when it comes to very research-intensive universities. As Aghion et al. note, there are, however, several university models in Europe and there is no unequivocal way of concluding which one is the best. Furthermore, as the latest UK Research Assessment Exercise has demonstrated, small world-class research teams do exist in the midst of institutions and departments that are otherwise of average calibre. Benefits of research come from working at the "frontier", as well as emanate from a broad basis. The organisation of universities needs to be such, however, that they become much more competitive, either for competitive funding, for students, or for industry/services. Especially for competitive research grants, individual researchers must be supported in an adequate way by their institution, while some institutions must be able to compete with other institutions among the best. On this basis, for Europe, Aghion et. al. recommend a combination of increased public funding for research, increased autonomy and increased mobility and competition as a way to improve research performance (see also section 1.6, Chapter 1).

Increased autonomy needs to be accompanied by increased accountability and transparency in evaluating results. Once universities are expected to classify themselves, it would be more conducive to measure their impact along a number of different dimensions. Among the relevant measures, the number and the attractiveness of the graduates they produce is certainly key. It is well known what industry/services treasures most: well-trained graduates, i.e. possessing the latest skills and knowledge plus, whenever possible, the ability to be flexible and continue learning. With regard to basic research, scientific publications and citations offer important parts of the toolbox for quality measurement, although their weight should be normalised with a view to variation across scientific disciplines, size of institution, profile etc. On top of this, there is a need for complementary indicators to disclose and measure the ability of universities to attract funding from external sources or to attract in other ways, thus enhancing its reputational capital. Again, universities must be requested to define their objectives and disclose progress made in multiple, alternative terms, based on solidly tested frameworks that allow for comparability and transparency.

However, what matters most for Europe is not to be "mechanically" better placed in the top when it comes to the ranking of individual universities. The key is to put in place stronger mechanisms for encouraging and allowing a stronger performance, and for a better organisation of universities to allow for differentiation and collaboration.

On this basis, policy measures need to be put in place that are capable of improving both the quality of research in European universities and to strengthen its impact, including the economic impact. References in patent documents, number of spin offs, number of high-growth firms created, the scope and success of resulting collaborative research, etc. can be applied to trace progress. The EC should work with member countries to develop the entire playing field, and to ensure that the mechanisms required for enabling and measuring progress in university performance are put in place.

One of the key factors that impact on the quality of research in universities and RTOs is the research environment and the structure and dynamics of academic careers. These, in Europe, still take place overwhelmingly in national contexts, dependent upon pension schemes, social security arrangements, recruitment channels and work conditions. A considerable effort has been made by the EU with its "The European Partnership for Researchers"[71]. The aim of this initiative is to accelerate progress in key areas including social security, competition based transnational recruitment and portability of funding, employment and working conditions and training and skills.

[71] http://ec.europa.eu/research/era/specific-era-initiatives_en.html)

It would be preferable to start by improving working conditions and leverage career prospects –e.g. institutionalising tenure track systems in European universities – instead of continuing to exhort mobility as a virtue independently of emphasis on other factors. That said, Europe still has low mobility of professors and researchers, and is lagging behind most of its competitors in that respect. However, in spite of limited availability of statistical data at European level it seems that we have made some progress during the last several years[72].

The ERC experience after two concluded Starting Grant rounds, and one Advanced Grant round, is telling. The UK remains number 1 as the country with the most successful host institutions (although not UK nationals). Apparently, UK institutions are highly attractive to foreign (mobile) researchers of the highest quality. This is partly because their university structure allows and furthers the early independence of young researchers. The UK also has a well-functioning grant competition system which is coupled, however, with teaching positions as a fall-back in case a researcher is not successful. The reverse case is found in Italy: a country that so far has few attractive host institutions, but Italian nationals hold top positions among the most successful national group (working largely outside Italy).

The ERC sees clear messages for universities coming out of these and other figures. Working conditions must be rendered such that they attract researchers from outside or enable those inside to compete successfully at EU level.

In addition, mobility is itself a heterogeneous phenomenon. As with other indicators of scientific productivity, e.g. publications, it can be shown that a large part of mobility is due to a small number of highly mobile (and extremely productive) researchers and professors. They are the ones who cross-fertilize. *One way to nurture mobility is, therefore, by giving incentives to recruit internationally, especially for younger faculty members, in addition to making working conditions sufficiently attractive.*

One of the main reasons for the attraction exerted by the US system when compared with Europe is that younger researchers in the US are given scientific independence much earlier. Of course the elements that make a system attractive are many and can only be changed in the long term. Some activity has been undertaken to improve this issue but Europe needs to do more. This is particularly true in those fields susceptible to be exploited by the market. *Universities have to be encouraged, even if it implies a change of legal rules, to install a more proactive recruitment policy. This should allow them to attract international talent. Such an active recruitment is considered central to improving the quality of universities. Therefore incentives should be put in place in support of high quality recruitment at universities and RTOs.*

3.5 Knowledge and innovation clusters

Examining the performance of universities and their contribution to the economy often brings up the question of the 'right' balance between basic and applied research (see also the Epilogue in the Policy Report, Part I). While basic research of fundamental nature is predominantly, but by far not exclusively, linked to universities, many researchers still seem to keep their distance from research considered relevant to markets. The traditional notion that public funding should support basic research constituting a public good is still prevalent in many European places. Similarly, private funding is there to support applied research whose payoff can be appropriated by individual firms. However, developments in science and engineering, for instance in the life sciences, have rendered such a dichotomy largely obsolete: the distinction between what is "basic" and what is "applied" is

[72] See *Key Figures*, 2008.

often quite unclear. Furthermore, excellent research requires, among other, economic valorisation through appropriate IPR arrangements leading towards innovation and in some instances collaboration with the private sector for effective knowledge transfer.

Valorisation is a field where RTOs play a very fundamental role, which could be reinforced in conjunction with efforts undertaken by some universities. For this purpose, appropriate forms of collaboration are needed to realise a win-win situation between universities and RTO's and enterprises. In the increasingly integrated innovation systems of knowledge based economies, public and privately-funded research are indispensable for the emergence, growth and ultimate robustness of what have become identified to be knowledge and innovation clusters. Universities and RTOs constitute a central node in these clusters, but perform much below their potential when finding themselves outside such a cluster.

Historically, links between research and innovation actors were situated either within a national, regional, or even a local context. A major change occurred when industry, with exceptions like the pharmaceutical industry, either greatly reduced its in-house research or ceased to do research altogether (while continuing with development). These changes have induced industry to turn to universities and RTOs for needed knowledge and graduates. This has put pressure on universities and RTOs to become and remain competitive at European or, indeed, at global level. Nurturing links between new knowledge production (research), development activities and innovation actors is therefore no longer an option, but has become a must[73]. To become selected as university requires a strong focus on strategic profiling of universities and RTO's leading to identification of their competitive edge, while acting according to the strategic orientation. Policy measures like the German "Excellence Initiative" have contributed to raising awareness in this regard, although the best balance between traditional research orientations and new combinations remains to be seen.

Changing attitudes might also be a matter of generations. Ambos et al. (2008) found, in a UK context, that successful university-industry collaboration occurred where (1) the scientific quality of the research project funded was high and (2) where the Principal Investigator belonged to the younger generation. While high quality choice is not a surprise, it is interesting to note that the older generation of professors was much more resistant towards cooperation with industry and also less able to follow research lines appreciated by industry. The younger generation, perhaps already used to the expectation of close collaboration in the UK, was much more open.

If fundamental research aims to produce new knowledge, the combination with industrial/services, relevant research may, through different mechanisms, enable combinations, that are more effective in producing improved new knowledge with a social impact. This is also visible in the spontaneous emergence of new mechanisms for knowledge sharing, such as "open innovation" discussed in the next Chapter. All this reinforces the idea that better linkages between public research and industry and services benefit the overall performance of the research and innovation system. It also adds to the need to introduce the notion of entrepreneurship along the graduate and post-graduate schemes including the involvement of research staff as a further strong motivation in the cooperation between the public and the private sector.

The important role played by RTOs in supporting technology diffusion and innovation in certain industries needs to be appreciated. RTOs have a particularly great capacity to adjust to the conditions in individual industries and to develop professional management specialised for industrial cooperation. At the same time, because RTOs tend to be more aligned with and be closer to existing industry, compared to universities, their research agenda may also be more overlapping with, and less complementary to, that of industry.

[73] See also Chapter 4 on open and global innovation practices.

In industries and countries where the linkages of RTOs to industry tend to be dominated by defensive purposes, the economic benefits are likely to be weaker. This makes it important to ensure that RTOs are capable of putting strong efforts behind processes of renewal and are not trapped in defending status quo. Universities, meanwhile, may be more inclined to produce research that my lead to innovation relevant to a range of industries, including emerging ones. In addition, the links between research and higher education that characterise universities may offer a number of advantages for industry, e.g., to the extent that graduates employed by industry thereby acquire valuable skills.

Knowledge transfers have been supported by all MS through a variety of instruments. Clearly, there is plenty of duplication and overlapping in the mechanisms applied, especially when judged from a European viewpoint. *Fewer, more focused and better linked instruments (including across national borders), based on genuine competition, should be encouraged.* In addition, European research policy should take into account and exploit the opportunities for specialisation and complementarity between RTOs and universities in generating valuable industrial linkages.

3.6 Research and innovation in New Member States (NMS)

In terms of university profiles, NMS have inherited one type of university: teaching oriented with weak R&D. The mission of the universities was seen to be to primarily prepare graduates with the knowledge and skills required by industry. R&D was most often undertaken within the academy or industry (branch) oriented R&D organisations. During the transition period there has been several developments which somewhat changed this profile.

First, there has been an explosion of HES in terms of enrolment rates but at the price of reduced quality. Second, an important development has been the emergence of private universities, and the establishment of colleges of tertiary education, mostly in the private sector. For example, Poland has 195 private institutions with enrolment of about 380,000 undergraduates. Third, R&D has strengthened but mainly at large and comprehensive universities. It is almost non-existent at private universities. Fourth, HES has become internationalised with expected far reaching effects on student mobility, quality and research excellence.

However, universities in NMS face several challenges in trying to fulfil their mandate of having to improve the quality of research and forge strong partnerships with the industry in R&D. If judged by international evaluations and different league tables the quality of higher education has been in decline in NMS in the past decade. This has been accompanied by scientific careers being seen as unattractive among the younger population, ageing of researchers population, and increasing pressure for the universities to actively contribute to the emerging knowledge based economy. Although the best performing research institutions and universities have already developed international connections, the majority of them are still operating largely on a domestic basis.

Generally speaking new member states, for historical reasons, have certain strands of first-rate research concentrated in academic institutions. On the other hand, links to industry have often been one-sided and excessively concentrated in supporting existing lines of business rather than to encourage renewal or a range of innovations. Science-industry linkages have thus played a different role than in the EU-15 MS. Opening national funding mechanisms directed to the institutional renewal of new MS will be important for addressing these problems.

In NMS, academy – industry linkages have been primarily encouraged through the expectation that universities will either sell their new products through university sponsored spin-off companies or that they will sell knowledge by patenting and licensing it to commercial organisations. Within this product-oriented mode perspective, it is expected that the university will generate knowledge that will be *directly* used in the innovation process. These expectations contradict empirical evidence from NMS innovation surveys, which show that universities are marginal to industry as a direct source of information for innovation. In that respect, the results of NMS innovation surveys are not different from results for other countries including EU15.

However, it seems that universities are much more important as an indirect source of information for innovation (Pavitt 1991). In terms of the Stankiewicz (1986) taxonomy, universities are the most effective in consultancy and R&D contracting mode *selling* problem-solving capabilities. This function is quite complementary to their role in informal knowledge transfer through professional networks. It is true that fundamental research in biomedicine and genetics has produced directly commercially relevant results. It is also true that software can be commercialised within or in conjunction with universities. However, this reasoning should not be extended to the entire spectrum of science and technology as the proximity of academic science to commercial application varies greatly.

The contribution of NMS universities to national innovation systems is much greater through the consulting and contracting than the product oriented mode. Their most important contribution is through the development of high level problem solving skills (Pavitt 1991). As the science base becomes essential background knowledge for all sectors, the universities' role in generating high level PhDs becomes an essential precondition for industrial research. If we take this broader notion of 'utilization' of knowledge, then NMS universities still have to make large strides towards this objective. Unsystematic evidence in NMS indicates that the consultancy and R&D contracting mode is the major part of universities' 'utilization' of knowledge activities. We do not know to what extent these are standardised knowledge intensive services and to what extent these are services which closely rely on the results of academic research. Case study evidence would suggest that in this respect, universities in NMS are substituting for the still undeveloped sector of knowledge intensive services. Universities are complementing extra-mural business R&D institutes in NMS which *de facto* operate as knowledge intensive service providers (Radosevic and Kriaucioniene, 2007). Often the informal character of this activity, which is undertaken by individual academics, and the lack of institutional involvement, makes it difficult to assess the scale and scope of this substituting function.

In an ideal model, the three functions of universities would reinforce each other. We would argue that, contrary to this, we observe substituting effects instead of complementarities between individual functions. As a result, universities are not operating as dynamic nodes in national systems of innovation in NMS. Evidence suggests that this trend is not unique to the NMS. According to Geuna (1997), many universities are driven by budget cuts to do routine contract research for industry which neither leads to high publications (and spillovers) nor lays a basis for long term fundamental innovations. The empirical evidence shows that this is the case for the NMS' economies where the highly developed higher education and R&D sector faces the challenge of economic survival. It is reorienting itself to market led activities, which in many cases are more routine and are application rather than R&D oriented. In summary, substitutive effects between different knowledge functions dominate over synergy effects.

When compared to the 'old EU15' situation in universities and R&D organisations in NMS differs more in terms of degree rather than quality. Hence, there is even stronger need for reform of HES in NMS in terms of greater autonomy, accountability and excellence. In terms of policy priorities research at universities should be further encouraged and criteria of funding should be much more based on criteria of research excellence. There is strong need to couple policies of support through Structural Funds with their participation in Framework Programmes and other EU programmes.

University R&D could be boosted by linking the curricula at MA and PhD level with research activities at academy institutes. A stronger integration of teaching and research would help to introduce students to research methods, and increase their interest and competence in professional work after graduation. In addition, promoting a shift to more applied research and practical problem-solving would provide a recruitment channel for students and companies.

3.7 Conclusions: policy implications and the contribution of ERA

Community policies for merit-based competition schemes among universities and RTOs at EU level.

The above discussions have raised a number of issues for policy implications and recommendations. Although responsibilities for universities and RTOs remain with MS and leaves a relatively minor role to the EC, a number of actions can be undertaken by the EC, on its own or together with MS.

The obvious advantage of the EU level with considerable European value added is that the more competitive, large, transparent and accountable the competition process is, the stronger the pressure towards better quality and hence the larger the impact will become.

A novel institutional funding model tied to specific criteria in a merit-based competition at EU level

Inventing new mechanisms is an integral part of adapting to changes in the larger environment, but great care must be taken that they will indeed provide solutions to the problems that have been identified. Support for institutions is certainly an idea whose time may have come, but many pitfalls are waiting in the details.

In general, there is far too little of a learning culture in the EC. When combined with a widespread risk-aversion on the part of officials (linked to personal liability in the Financial Regulation) organisational and strategic innovation tends to become stifled. The overly ‘bureaucratic’ ways of the Commission must be genuinely reformed and simplified, and not just ‘outsourced’ under the guise of Executive Agencies. One of the main obstacles, and determining the ways in which the Commission now operates, are the financial rules imposed on the Commission. They have introduced a management culture which lies largely based on mistrust.

- The revision of the Financial Regulation planned for 2010 should therefore include a derogation for research, whose management culture rests on trust. Progress in this regard would be of great importance since it could radically improve the efficiency of the funding system at European level. It should also consider that the rotation principle within the Commission may have detrimental effects on DG Research. It may therefore be advisable to derogate certain rules of the staff policy for the benefit of research policy and implementation, while of course making sure that accountability is guaranteed as far as the use of public funds is concerned.
- A clear setting of priorities at EU level and a strategic reconfiguration of what is predominantly left to MS is urgently recommended. The ‘one size fits all’ has never been a valid, nor a good principle. In order to enable universities to test and improve their governance and to foster their strategic capabilities in university management in a professionalized way, we recommend setting up a merit-based competitive scheme at EU level for universities (and RTOs) which provides funding with considerable European added value for those institutions that excel on a number of clearly defined dimensions. MS may want to join forces in preparing their universities by including criteria that will enable

universities to better compete at EU level, e.g. within the pluri-annual performance-based contracts now negotiated between universities and their governments or intermediate bodies.

- Incentives should include measures to support high quality recruitment at universities and RTOs, encouraging them to install a more proactive, international recruitment policy.

Ph.D. training: a competitive scheme for European doctoral schools

- One of the keys for raising the overall quality of research at universities is the improvement of their Ph.D. training through a mechanism of competitive funding for Ph.D. programmes. It could include competitive institutional funding for the best Ph.D programmes, based on criteria aiming for excellence and the improvement of the career prospects of the future generation of researchers in Europe as well as their working conditions.

Strengthening the basis of basic research and innovation at European universities and RTOs through Community policies

The impact of the ERC on universities and RTOs

Generation of frontier knowledge is an indispensable precondition for the value chain and the future well-being of our societies. It has been reinforced at European level through the radical policy initiative taken by the EC in setting up the European Research Council (ERC). Its success, within a very short period of time, has been widely acknowledged, both within the scientific community, as well as by MS and the EC. In order to build upon this success and to guarantee its sustainability, the Final Report to review the ERC's structures and mechanisms "Towards a world class Frontier Research Organisation" issued on 23 July 2009 has made a number of recommendations.

- We urge the Commission to implement these recommendations and, in particular, to guarantee the independence and efficient operation of the ERC beyond 2013 in an optimal and sustained way. Towards this end, the ERC has to receive a higher overall budget and should become an operationally integrated, autonomous European institution sui generis, making it a truly world class frontier research funding organisation.

Fully integrating RTOs in the ERA

RTOs turn out to be crucial for the success of the ERA because of their fundamental role for both research and innovation. In particular their role in national innovation systems is important. The competition of RTOs in the market of contract research, the structural cooperation with universities, the benchmarking with peers among others would benefit highly from a better integration into the ERA.

The Commission should be more cogniscent of the importance of RTOs in the innovation system. Therefore, incentives to RTO-RTO cooperation and RTO-University cooperation are strongly recommended. This will reduce fragmentation and reduce overlap, and stimulate cross border cooperation in projects and research facilities. At the same time RTOs would benefit from continuity of funding programmes on collaborative research with emphasis on knowledge transfer that already in place. RTOs are well equipped to respond to such challenges.

Europeanization of research infrastructures

While Community policy on research infrastructures aims to an improved coordination leading to possible integration, so far the EU contribution to national research infrastructure resources has been limited to contributing a few percent of the cost of opening up access to all researchers. ESFRI is a purely advisory body set up at the request of the Council bringing together the representatives of research ministers and a representative of the Commission; it has a mixed intergovernmental /

Community approach to develop and support a coherent and strategy–led approach to policy making on research infrastructures in Europe and to facilitate multilateral initiatives leading to better use and development of research infrastructures, and on whose advice the Commission and Member States may act. The development by ESFRI of a European Roadmap for RI has induced several countries to develop coherent national roadmaps mutually connected through the ESFRI roadmap, thus producing a growing trend towards integration and upgrade of national resources, including existing potentially relevant infrastructures.

Recently, moreover, the Council has adopted a specific legislation at Community level (Council Regulation n° 723/2009 on the Community legal framework for a European Research Infrastructure (ERIC)) that will allow greater institutional integration of national resources, as well as some exemptions already available for international research organisations. This is a very welcome initiative since a mechanism to deal with European research infrastructures is definitely needed. Again, lessons learnt should be used in designing a truly European approach that goes the beyond predominant nationalism .

- The initiative on RI is a positive recent development of EU research policy although the decision making process is still far from efficient. In order to be able to attract the best researchers, RI must be international and develop both the highest scientific-technological competence and adequate management capabilities in a competitive environment. Supporting transnational infrastructures and granting international access to national facilities is an important point. It should be reinforced, and attracting the best researchers to and from infrastructures on a competitive basis should become a key indicator.

Joint Research Initiatives

The “Expert Group on the Future of Networks of Excellence” recommends to discontinue the scheme (with very few exceptions where funding on a small scale is envisaged). For the future, it proposes a revised concept “Joint Research Initiatives” (JRIs), oriented towards long-term academic research of ‘slender’ alliances between universities and research organisations. The objective of JRIs should be the creation of ‘virtual institutes’ of a medium, manageable size of 3 to 7 partners. These virtual institutes should be committed to joint long-term research planning and activities, with a typical duration of 7-9 years. The expert group sees them as complementary in a two-fold sense: to the industry-led Joint Technology Initiatives (JTIs), as well as an institutional complement to the ‘individual excellence’ supported by the ERC. This would also be in line with the EIT mission of creating “Knowledge and Innovation Communities” (KICs) in priority areas to engage in world-leading innovations and to produce highly qualified people with the right entrepreneurial and proactive skills and values.

- The difficulty to coordinate national policies and undertake joint actions (although several examples show that we can do it if there is political will) is clearly a major weakness in the EU research policy. Therefore we support the JRI scheme which should be mainly implemented in a ‘bottom-up’ competitive mode (with a ‘top-down’ approach of very limited extent in selected strategic research, e.g. the Grand Challenges) and would thus be committed to enhancing ‘institutional excellence’.

In addition not all research infrastructures are large and have physical embodiment. Increasingly, scientific communities build up forms of coordination that deal with sharing equipment, pooling datasets, setting up a shared research vision, establishing experimental protocols, validating laboratory procedures and developing Standard Operational Protocols (SOPs). All these activities do not directly produce scientific output, but produce “intermediate collective research goods”, i.e.

goods that are used by other researchers to improve research productivity. In most cases these goods are intangible.

- We support the policy proposals made by the "Expert Group on the future of Networks of Excellence" to launch Joint Research Initiatives (JRIs), as voluntary, self-administered coordination mechanisms to produce intermediate collective research goods in a synergetic manner with the continuing development of Research Infrastructures of pan-European interest. A particularly strong reason for supporting the production of such scientific goods is the need to counter-fight the fragmentation of the institutional and regulatory environment across European countries, which in many fields makes it more difficult to produce valid and generalizable results.

Knowledge and innovation clusters
Funding knowledge transfer has been tackled by MS through a high variety of instruments. Probably there are more mechanisms available than can be managed. Therefore, fewer and more focused instruments, based on genuine competition should be encouraged. One of the mechanisms has to deal with helping in the development of knowledge-intensive companies and building ecosystems that concentrate effort around the leading universities and RTO's.

- The importance of research technologies, i.e. research instrumentation and new methods that have been invented or set up for purposes of research, mostly in the lab, but that carry an inherent potential for wider use outside the lab, is not sufficiently recognized. In order to realize their cross-cutting, integrative potential, either for other research fields or, perhaps even more important, for industry/services in innovative ways, flexible opportunities need to be created that allow industry, academia and RTO's including research infrastructures to jointly explore already at an early stage how basic research, applied research and innovation and entrepreneurial activities in general might be transformed into 'experimental innovation'. This includes the search for new forms of practice, e.g. how to use, adapt or transform research technologies for purposes and objectives outside the laboratory. Research technologies come with the skills and knowledge of those who have been trained to use them, hence the importance of well-trained graduates.

Establish the balance between funding excellence and R&D relevance in NMS
NMS' R&D funding systems have made significant progress towards openness and excellence. Access to the Research Framework Programmes and other EU sources of R&D funding has stimulated the drive towards world excellence. While funding efforts and performance of high level research remain important, ensuring industrial and social relevance has been given insufficient priority, which is a cause for concern and will not ensure innovation relevant to the economies and societies of the NMS.

- Research capacities should be linked to firm level demand through an increased share of co-funding mechanisms involving the business enterprise sector. Co-funding schemes can help connect pockets of scientific excellence with the business sector. Co-funding can also enhance the impact of science parks, high-tech incubators and other similar initiatives. Building applied research capacities in the public sector and capacities for supporting technology absorption and technology development in close cooperation with commercial enterprises should enhance the competitiveness of firms in NMS.

Chapter 4:
Global networks of open innovation and the ERA

4.1 Introduction: *Open innovation as a new paradigm*

Innovation processes can involve a wide range of actors, including firms, universities, research and technology organisations (RTOs) that may be public or private in nature, as well as customers, consultants and suppliers. Open innovation marks a departure from previous mainstream approaches to innovation. Although the basic objective ("take advantage of resources other than your own") is not new, approaches to support this objective have changed considerably and have become more diverse, thereby shifting the balance between in-house activities and the use of external resources in response to the growing complexity and melting together of product and service categories and to growing competition.

These changes were already visible in the 1990s, and were first coined as a new paradigm by Chesbrough (2003) in terms of the commercialisation of external (as well as internal) ideas by firms' deployment of outside (as well as in-house) pathways to the market. The perspective was then developed further by pointing out its two-way nature: the inward leveraging of the discoveries of others, and the outward search for organizations with business models that are better suited to commercialise a given technology than the firm itself (Chesbrough and Crowther 2006). Activation of internal capabilities is strengthened by complementing them with external inputs, and by identifying external returns for projects that no longer correspond to the firm's strategy.

This Chapter considers the changing nature of the business innovation practices, the relation between these practices and research and development, and the implications for European policy.[74] In particular, it focuses on open innovation and internationalisation of R&D as key challenges for innovation processes. The chapter explains the concept of open innovation, assesses its current advancement, and examines how open innovation may interact with the internationalisation of R&D to generate global innovation networks. It then examines some of the current policy instruments and funding schemes that are intended to improve the innovation ecosystem in Europe and concludes with recommendations on how these policies might be improved.

4.2 Understanding Open and Global Innovation Processes

Use of the term "open innovation" has become quite commonplace, but the phrase can still be misleading. Any discussion of innovation processes requires consideration of the collaborative architecture, and recognition that part of what is termed "open" innovation takes places in relatively closed structures, in the sense that the activities are based on restricted company-to-company agreements with the conventional commercial objectives of profitability and defensibility. Open innovation is not equivalent to open science, nor does it correspond with open source software (in the ICT area). Intellectual property rights remain important, although the way these are managed may change to reflect the collaborative architecture and business goals.

[74] Chapter 1 explored the European gap in business sector R&D mainly from the perspective of aggregate national data.

Pisano and Verganti (2008) distinguish between the truly open collaboration that can include virtually anyone in the architecture (the participant decides to participate, as seen in e.g. crowd sourcing) and closed networks, where (normally) it is a company or existing consortium that decides who to select and involve in the innovative activity. It is generally the second approach that is seen as providing the primary evidence for firm's open innovation practices. This is because firm's innovation networks, while not being totally open, have become much more important and central corporate laboratories have become more open to various types of co-operations.

Figure 4.1 highlights the two directions of open innovation. Inbound open innovation can be reflected in the extent of R&D collaboration (private-private and public-private), licensing in, venturing and acquisitions. Outbound open innovation may include licensing-out, the provision of R&D services, spinouts and divestments. As further illustrated in figure 4.1, firms can apply a range of tools to access a broad array of knowledge sources. In some situations, research partnerships, with both firms and academic institutions, are used to complement in-house R&D capabilities with specific competences. In other cases, collaboration is aiming at cost and risk sharing. Partners are selected depending on the precise objectives or problems pertaining to the firms' needs or problems (Miotti and Sachwald 2003). Firms also buy licenses during the process when they identify patents corresponding to their needs. A company can also identify potentially-interesting external projects and follow closely their evolution through venture capital investments. Finally, companies can buy a more mature firm when they consider that its competences are necessary or particularly promising.

As innovation processes become more open and distributed across geographies, and associated with increasing levels of collaboration and outsourcing, the linking of actors in the business eco-system becomes of fundamental importance (Howells, 2006). Considerable research insights already exist on the inbound side, whereas the outbound side is less developed. A set of actors, known as innovation intermediaries, have specialized in establishing links and stimulating cross-fertilization in business networks. Innovation intermediaries perform a range of roles including articulation and selection of technology options, scanning and locating new sources of knowledge, introducing existing technologies in new industries and for new applications, building linkages with external knowledge providers and development and implementation of innovation strategies (Bessant and Rush, 1995). Howells (2006) additionally stresses the role as brokers for commercialization, foresight and standard setting. These roles imply that innovation intermediaries cover a broad range of activities, which all are relevant as stimulators of opening up the innovation process. The innovation intermediaries may therefore assist in accumulating relational capabilities across the range of actors within the business eco-system and thereby broadly promote open innovation practices.

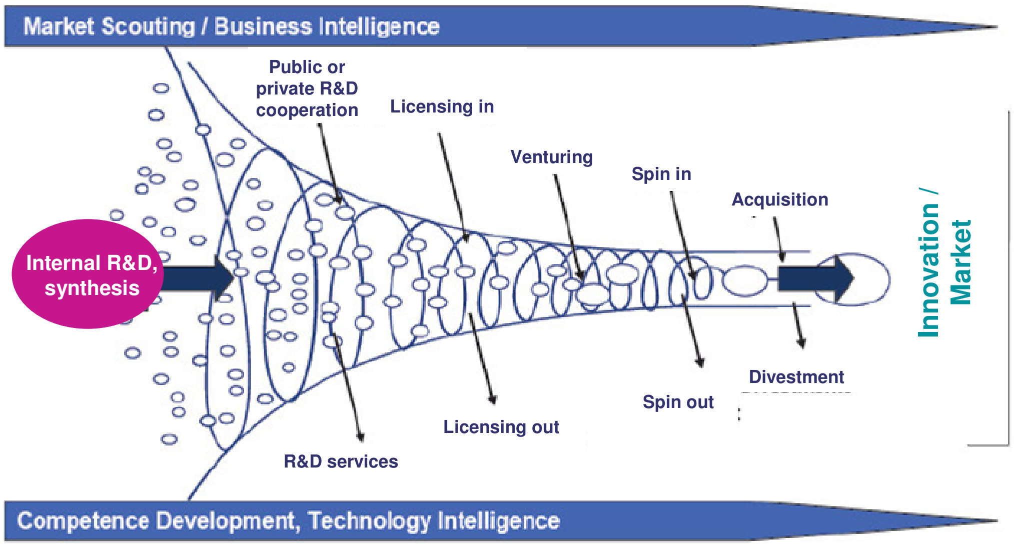

Figure 4.1: Open innovation tools along the innovation process
Source: de Jong (2007)

The *relevance of this paradigm for the KBE* derives from a widespread belief that openness accelerates innovation by being potentially faster, cheaper or less risky by taking advantage of resources other than the ones in possession of the firm.

In summary, open innovation offers the potential for firms to access a much broader scope of knowledge and ideas than could be generated by its in-house R&D capabilities alone. It can substantially reduce the cost of innovation, whilst accelerating the process. Lastly, it can enable companies with mature markets and technologies to successfully introduce more radical technological and organisational innovations.

4.3 Dissemination and impact of open innovation practices

The available indicator data on open innovation practices is of variable quality and comparability; furthermore outbound approaches seem less extensively analysed than inbound (OECD 2008; Zuniga and Guellec 2009).

Collaboration with different types of partners

National innovation surveys provide one set of data for making cross-country comparisons. In these surveys, collaboration is defined as an active participation to common innovation projects with other organisations and does not include e.g. R&D sub-contracting. Collaboration can involve the development of new products or processes with customers or suppliers, as well as common R&D projects with competitors or academic laboratories and universities.

Table 4.1 illustrates the propensity to collaborate across countries and that these vary substantially. Companies from small countries in the north of Europe collaborate more than those from the larger European countries and those from Japan. Larger companies collaborate much more to innovate than SMEs. This conclusion has been confirmed by empirical studies, which found that the extent of R&D collaboration is correlated with firm size, whatever the sector[75]. A recent survey (UNECE 2009) confirmed that collaborative modes of open innovation are more often found in mature rather than early stage companies. Their lower propensity to collaborate may be explained by SMEs' scarce human and management resources or by their weaker absorption capacity. Equally, contracting between counterparts depends on their relative bargaining power, which in turn depends on a variety of cultural, economic and regulatory factors that may easily disadvantage younger ventures.

	All population	Industry	Services	SMEs	Large companies
Denmark	22.2	24.6	20.0	20.8	53.9
Sweden	21.4	26.0	18.6	20.0	53.5
Finland	19.2	23.4	14.8	17.3	56.1
Belgium	18.3	22.0	14.9	16.6	60.9
United Kingdom	15.8	14.7	16.7	15.3	27.7
France	12.9	14.1	11.7	11.6	43.6
Netherlands	12.8	18.4	8.4	11.6	45.3
Norway	12.3	15.8	9.3	11.3	36.9
Germany	10.4	14.2	7.0	8.6	36.3
Switzerland	9.9	16.6	5.9	9.4	22.2
Austria	9.1	10.8	7.6	7.7	40.2
Japan	7.4	8.4	6.2	6.5	27.9

Table 4.1: Companies collaborating on innovation activities (percentage of all companies, 2002-04)
Source: OECD (2008)

Companies from industrial sectors tend to collaborate more to innovate than do service companies, and collaboration is particularly intense in high tech sectors (Hagedoorn 2002, Miotti and Sachwald 2003). The extent of collaboration also varies according the different types of partners. Table 4.2 shows that those firms that cooperate tend do so first with their suppliers and their customers. Collaboration with competitors is less frequent (but it is important to keep in mind that companies may compete with one another in some areas and collaborate in others). Collaboration with public research organisations, universities or institutes, is also less frequent. However, significant differences are observed among countries.

These differences may partly be explained by the national sector distribution. For example, Finland is specialised in ICT, where collaboration to innovate is particularly prevalent because of the short technology cycles. Firm size may also be an explanation in some countries. Characteristics of the national innovation system may also contribute to these differences. Both the quality of academic research and its openness to business vary noticeably between countries and this could also be a factor in the variable diffusion of partnerships between public research and companies.

[75] See particularly, Miotti and Sachwald (2003), Laursen and Salter 2004, Dhont-Peltrault (2005), Herstad *et al.* (2008).

	Suppliers	Customers	Universities	Public institutes, government	Competitors
Finland	92	93	75	59	77
Czech Republic	80	68	37	26	40
Sweden	75	65	41	15	25
Netherlands	75	55	31	24	31
United Kingdom	74	73	33	25	36
Belgium	73	59	37	26	27
Hungary	71	53	37	14	37
Denmark	66	65	32	16	35
France	65	50	26	18	36
Italy	56	39	36	11	37
Spain	52	23	26	28	17
Germany	44	51	53	26	27
Austria	43	45	58	30	22

Table 4.2: Companies collaborating on innovation activities, by partner (percentage of all companies collaborating on innovation, 2002-04)

Source: adapted from OECD (2008a)

While there are also other explanations, including prevailing incentive structures as influenced by the regulatory and financial policy frameworks, the lower propensity of companies to collaborate with academic research institutions can in part be explained by the nature of such collaborations. Firstly, upstream collaboration focus primarily on the exploration phases of the innovation process (Bercovitz and Feldman 2007). Such upstream research typically represents a relatively low share of the total innovation process in companies, compared to the resources devoted to development. A survey of 605 innovative Dutch SME's explored eight open innovation practices[76] and provides complementary results (Van de Vrande et. al. 2009). It showed that employee involvement, customer involvement and external networking were utilised much more frequently than the other practices. Especially, licensing (inward and outward), which typically result from R&D investment, was utilized less frequently (20% and 10% respectively). The fact that interactions with customers and clients are the most frequent is consistent with the fact that R&D activities represent a relatively low share of the innovation process.

Co-operation with public research appears to play a specific role, as suggested by a study based on British data (Laursen and Salter, 2004). Universities are used to source knowledge to innovate by a relatively small number of companies operating mainly in certain industrial sectors (pharmaceuticals, chemicals, machinery, transportation, and electrical and electronic equipment). Furthermore, the companies that collaborate with universities invest in both their internal R&D capabilities and the development of open innovation practices. Similarly, Tsai (2009) found that absorptive capacity positively affects the impact of collaboration with research organisations on the performance of marginally changed products. He argues that firms with insufficient absorptive capacity cannot easily jump into totally new areas of technology.

These results confirm that companies that cooperate with universities also develop ambitious innovation strategies. Such firms may also be the more likely to generate radical innovations. But these companies are relatively few and they focus their collaboration on upstream academic research. As a result, this aspect of public-private collaboration may be limited in volume, but qualitatively very important.

[76] These include venturing, outward IP licensing, employee involvement, customer involvement, external networking, external participation, outsourcing R&D and inward IP licensing.

The role of academic research for company R&D can also be measured through patent data. A recent study uses the OECD patent data base to measure the degree of co-location of the inventors of the patents[77] filed by companies on one hand and by academic research organisations on the other hand (Guellec and Thoma, 2008). It shows a positive correlation between the number of patents from academic origin invented in a region and the number of patents invented by companies in the same region[78]. The importance of academic patents is stronger at the intra-regional level. It is also stronger at the industry level, which suggests that intra-region interactions are important in specific fields. Furthermore, the correlation is stronger in sectors that rely more directly on scientific activities, pharmacy, chemistry and instruments[79]. Finally, the correlation has increased between the beginning of the 1990s and the beginning of the 2000s.

This evolution coincides with the development in different countries of public policies that have favoured concentration in clusters. It is consistent with the development of open innovation practices by companies, in which priority is given to those favourable environments that offer a sufficient concentration of academic organisations producing relevant inventions. Further studies are required to establish the determinants of these correlations between academic and business patenting patterns.

Outsourcing of R&D activities

The share of R&D outsourcing provides a simple indicator of one aspect of open innovation. However, there is no comprehensive statistical series that follows its evolution over the long term and across different countries. The following is therefore based on non-comprehensive collections. Surveys among the top EU R&D-investing companies in Europe measure an increasing outsourcing rate. An exceptional figure of 30% was recorded in 2007, although this value was sample-dependent. (Companies from sectors such as pharmaceuticals and ICT tend to outsource more R&D.) A figure of 18% seems a better estimate of the overall current situation[80] (EU 2006-2009). Two-thirds of outsourced R&D goes to other companies and one-third to public research organisations.

More general surveys involving representative samples of firms indicate lower outsourcing rates. At the beginning of the decade, outsourced R&D spending was 5% in Austria, 8% in Belgium, 10% in Denmark and 12% in Norway (Herstad *et al*. 2008). Such figures are close to the share of R&D expenses outsourced to non-affiliated companies in national statistics. Indeed, outsourcing to independent local or foreign subcontractors and to academic research represent generally less than 10% of business R&D spending.

A German study of 1663 firms reported that 3.6% of all companies with R&D activities outsourced parts of these activities from 2004 to 2006 (FHG-ISI 2008). Among firms with more than 500 employees the share was 13.8%; among small companies with 20-99 employees the share was 2.9%. This study also explored the main motives for outsourcing of R&D and mentioned the two most important as capacity bottlenecks (58%) and cost of human resources (53%). By comparison, the large EU firms responding to the 2007 survey on EU R&D Business Investment Trends argued that by far the most important reason to outsource R&D was to access knowledge and results (EU

[77] Demands submitted to OEB and PCT. Inventors' addresses are filed in 330 regions of OECD countries, or in 1700 zones of the type French '*département*'.
[78] The estimate includes control variables for the year of filing, the sector and the country of origin.
[79] The patents can also play a role in the strategies of protection.
[80] Samples are different from one year to the other.

2008). These perspectives may not be as different as they seem on the surface, possibly reflecting only a different emphasis on the relative importance of in-house and external resources.

The available data suggests that outbound practices are less developed than inbound ones (OECD 2008). Some companies have nevertheless systematically developed their out-licensing operations and a greater number have at some time tried this approach (EIRMA, 2002). Whereas the success of both inbound and outbound practices may involve cultural adjustments by the firm, it seems that outbound practices tend to require the greater adjustment. So-called "corporate venturing" requires a specific managerial mindset which is quite different from those required to run other managerial processes. The EIRMA study found the degree of interest in corporate venturing was influenced by product life cycle (short cycle = more interest); complexity of product/technology (more complex = more interest) and phase of technology cycle (incremental versus disruptive growth). In high tech sectors, acquisitions by large companies mean that start ups and SMEs are involved on the outbound side. More generally, the symmetrical perspective can be adopted for R&D outsourcing.

Impact of open innovation practices

Drawing on results from national innovation surveys, Herstad *et al.* (2008) designed a synthetic indicator of open innovation. This approach is supported by the work of De Backer *et al.* (2008), who have suggested using composite indicators to analyse more complex interactions in research. The indicator aims to summarise the intensity of various open innovation practices: R&D outsourcing and licensing-in, collaboration, search for information on external resources and the use of instruments to protect intellectual property. For the first three practices, the indicator includes both an intensity factor and a diversity factor that depends of the variety of the partners or sources of information. Computations have been harmonised for four countries, Austria, Belgium, Denmark and Norway. The study found that *it is primarily the overall openness of organizations which impact positively on innovation performance, in addition to intramural R&D and international collaboration within the value chain, i.e. with customers or suppliers. The study continues to argue that from the firm perspective, the ability to tap into, absorb from and serve as gravitation points within such networks is contingent on a strong, internal capacity. From the economy perspective, this capacity is essential as it serves to "anchor" companies to economies of origin and as it produces knowledge spillovers into these economies* (Herstad *et. al.* 2008).

An estimation based on the results of the UK innovation survey showed that companies with the more active strategies of search for information exhibit a stronger innovation performance (Laursen and Salter 2006). Companies that resort to multiple information channels and use them intensely have a higher probability to produce radical innovations.

These various studies find a positive contribution of in-house R&D expenses to innovation, but also clearly identify an additional contribution of open innovation practices. Evidence on open innovation is building up progressively, but more coordinated data collections are needed to better assess the European potential and needs for policy interventions.[81]

4.4 Internationalisation of R&D and networks of innovation

Another dimension of open innovation particularly relevant for the development of the KBE comes from the internationalisation of companies' R&D and innovation activities. Since the 1990s, the trend towards internationalisation has accelerated, and companies have set up and expanded their R&D centres in a growing number of countries. Foreign R&D activities have also become more

[81] See also recommendations in EU 2007b, EIRIMS Expert Group.

diverse and companies develop global networks through their own research locations and international partnerships.

The expansion and diversification of foreign R&D centre

The internationalisation of business R&D continues largely to follow the development of production in new areas, which leads to the need to adapt to local markets (CNUCED 2005, OECD 2008a). Yet, access to local scientific and technological resources has motivated a growing number of R&D centres abroad.

Over the last twenty years, European and Japanese companies have used their subsidiaries in the United States to draw upon the resources of the American innovation system in high tech sectors. Different studies have thus shown that the establishment of R&D in the United States had a positive impact on their production of patents in these sectors (Almeida 1996, Frost 2001, Sachwald 2003, Iwasa and Odagiri 2004). A study has also shown that the productivity of British companies investing in R&D investments in the United States in the 1990s grew as a result (Griffith *et al.* 2004), suggesting that these transatlantic investments were more efficient in terms of improved productivity than the R&D investments made by these companies in the United Kingdom (see also Chapter 1).

The behaviour in term of access to technology through investment abroad has progressively developed and gained in sophistication. In particular, companies have tried to better integrate their various R&D capabilities into their innovation strategies. The relative importance of different trends varies depending on companies' sectors and countries of origin, and this makes the identification of the different motivations of R&D internationalisation more complex.

Beyond the factors that initially determine the location of R&D centres, their activities also evolve over time. Centres develop relationships with their local environment and, depending on the latter's characteristics, this can enhance their own innovation capability. So, even if the establishment of a R&D centre was justified largely because of the importance of the local market, its subsequent development may hinge on a co-evolution with local scientific or technological capabilities.

This sequence has been verified in the case of the foreign subsidiaries of American companies between 1991 and 2002 (Hegde and Hicks 2008). The likelihood of establishing a R&D activity in a specific country depends first on the local market. On the other hand, the likelihood that the local R&D centre files patents depends more on the local technological capabilities, measured by the number of American patents attributed to the inventors of the country[82]. Finally, the number of patents filed by a subsidiary, representative of its innovation capability, depends essentially on the scientific production of the host country, measured by the articles published in sciences and engineering[83].

Symmetrically, studies based on patent data have shown that the European and Japanese multinational companies effectively benefit from the American scientific and technological capabilities, thanks to their centres in the United States (Almeida 1996, Iwasa and Odagiri 2004, Griffith *et al.* 2004). The relationship between R&D units in different countries varies, however.

[82] The authors have subtracted patents attributed by the American office (USPTO) to inventors from a given country, those that have been attributed to American multinational companies. They use fractional accounts for the patents with multiple inventors.
[83] The article distinguishes between nine industrial sectors, for which the nomenclature differs from that in scientific articles. The authors calculate a relevance ratio for each scientific field in each sector based on quotations from articles in the patents of the sector. The local publications in a given field are weighed by this ratio.

Analyses of R&D expansion abroad by multinationals based in the Nordic countries have demonstrated both cases of complementarity with R&D in the home country, and evidence of substitution effects (Andersson, 1998).

Looking at large companies with a strong R&D base in Europe, recent surveys of R&D Business Investment Trends by larger firms with a strong EU base (EU 2006-2009) draw a number of consistent conclusions. For example, the 2008 survey, drawn from a sample of 130 (larger) companies from various sectors accounting for 30% of the EU's business investment in R&D, reports that:

1. The companies carried out over 20% of their R&D outside the EU. The largest share of foreign R&D investment (almost 10%) went to the US and Canada. The percentages of R&D investment carried out in China and India were 2.7% and 3.5%, respectively.
2. Expectations for growth in R&D investment within the EU were the highest (4.6%), ahead of Japan (4.4%), the US and Canada (4.3%), other European countries (3.8%), India (3.2%), RoW (3.1%) and China (2.5%). In the 2007 survey, R&D investment growth expectations were the lowest in the EU (6%) and higher in the US and Canada (10%), Japan (15%), and India (17%).
3. The companies surveyed generally indicated their home country as the preferred location for R&D, and identified Germany, the US, and India as the most attractive locations outside their home country.
4. Availability of researchers and access to specialised R&D knowledge are main drivers affecting decisions about R&D location, especially in high tech sectors. The cost of employing researchers plays a small role overall, but is an important consideration for those companies preferring a location outside their home country.

International partnerships to innovate

Data from innovation surveys indicate that for European companies substantial share of their co-operations are with foreign partners, particularly in industry (table 4.3). For example, 19% of the Finnish companies collaborate to innovate (see table 4.1) and 13% do so with foreign partners (table 4.3). Logically, the relative propensity to cooperate with foreign partners will be weaker in larger countries, but this is also the case in Switzerland.

Co-operations with foreign, including distant, partners have a positive impact on the propensity to innovate. The empirical analysis done in Northern European countries already quoted (Herstad. e*t al* 2008) measures a positive impact of the international collaborations with customers or suppliers on the propensity to innovate. This impact is constant and stronger than that of the national co-operations and of the international co-operations with competitors.

	Industry	All	Large	SMEs
Finland	16.9	13.3	51.6	11.2
Denmark	16.5	14.8	44.2	13.5
Belgium	15.7	13.5	51.0	11.3
Sweden	14.2	11.4	45.3	9.9
Netherlands	11.8	7.6	35.6	6.6
Switzerland	11.0	6.4	19.1	6.0
Norway	10.1	7.9	27.4	7.1
United Kingdom	7.8	7.7	19.7	7.2
Germany	7.6	4.8	32.4	2.9
France	7.4	6.2	31.9	5.0
Austria	6.1	5.3	30.2	4.2
Japan	1.6	1.2	9.9	0.9

Table 4.3: Companies having partnerships to innovate abroad in 2002-04 (% of all companies)
Source: OECD (2008)

For EU companies, the share of the extra-European collaborations is logically lower than the share of the intra-European collaborations (OECD 2008a). Indeed, the international economic relationships are always likely to be more costly and uncertain to maintain, and even more so when they are more distant. Still, the geographic distribution of the co-operations does not provide useful information on the qualitative aspects and the respective importance of the different types of collaboration. Insofar as distant partnerships are more costly and difficult to manage, companies which use them are likely to be highly motivated and putting a lot of demands on the distant partner.

4.5 The dynamics of global networks of open innovation

The interactions between openness and internationalisation of firms' innovation process support the formation of global open innovation networks. These networks reach more globally and are more integrated than previous R&D activities by multinationals, which mainly involve small networks of the firms' own R&D laboratories, relatively small-scale collaborations with limited groups of universities, and the acquisition of technology as a distinct commercial activity. In the following, these possible interactions are explored further focusing on the links and the drivers of global and open innovation networks.

Table 4.4 summarises the drivers of open innovation and internationalisation of R&D, revealing that both trends depend simultaneously on supply and demand factors and reflect changing preferences in respect of business model and corporate management.

Incentive to:	Demand side	Scientific and technological supply
Develop open innovation practices	1. Acceleration of the innovation cycle; increasing demand for innovation 2. Hybrid or complex innovations, including interactions between products and service 3. Evolution of the business model. 4. Growing attention to demand or customer driven innovation, including in services	1. Increasing supply of technologies, in particular from new firms and knowledge intensive services 2. Internal focus on defendable core competencies in face of growing external competition; limited R&D resources 3. New practices and methods of exchange of data, of simulation…etc.
Establish or increase research and/or development capabilities outside the home base	1. Importance of the local market (size, purchasing power) and implications for differentiation of products/services 2. World leading local market	1. Increased global availability of high quality S&T human resources and infrastructures 2. Excellence centres and good relations between academic research and firms in foreign countries 3. Good cost-efficiency ratio for some R&D activities in foreign countries 4. Increased capacities, qualities and cost-effectiveness of supporting ICT services

Table 4.4: Factors of openness of the innovation process and internationalisation of R&D activities

The increasing *demand* for innovation has exerted a growing pressure on companies' R&D capabilities and the managerial competencies that bind R&D into the overall business process. In various sectors, the evolution of the business models and the importance of services have challenged the traditional (technology-dependent) view of innovation and led to new combinations such as product-service offerings and business process innovations.

The increasingly multi-disciplinary nature of innovation provides another factor driving the opening-up of the innovation process, while locating R&D centres in leading markets can increase the firm's capacity to monitor the evolution of global demand and increase the legitimacy of that firm's presence in the local market.

On *the supply side*, the emergence of new specialised firms reinforces the development of new technologies as the market grows. These trends stimulate R&D outsourcing or the substitution of in-house capabilities with efficient third-party facilities and software. Increasing foreign R&D capabilities means that some of the externalisation can take place abroad, particularly when the centre(s) of excellence in a research field are located there. The shortage of in-house resources has also strengthened the trend toward externalisation and specialisation of the firms' R&D operations, but also the relocation of some operations. Similarly, cost optimisation has encouraged sub-contracting and relocation of certain activities into centres that can offer greater cost-efficiency e.g. where salaries are relatively low but performance is sufficient to achieve high-quality results and good integration into the firm's global operations.

The efficiency of innovation networks depends on their capacity to integrate innovation processes effectively, and on companies' ability to combine these processes with a relevant and timely perception of demand. A major challenge is to maintain the right balance of in-house R&D activities to sustain the firm's absorption and anticipation capacities. A further challenge is ability of the companies to secure the appropriability of knowledge-related investments.

Combining the available empirical results indicate that the degree of both openness and internationalisation varies along the *innovation process, across sectors and firm sizes*. Based on numerous case studies, the OECD (2008a) concluded that outside-in openness is at its highest upstream and diminishes as projects progress and applications are being developed. Empirical studies further suggest that partnerships with academia tend to focus on this upstream end and the most R&D intensive sectors (see chapter 2 for extent of use). Furthermore, case studies confirm that companies tend to be both more widely open upstream and to focus their partnerships with universities on exploratory activities (Sachwald 2009). Finally, companies engaging in radical innovation processes tend to benefit more strongly from alliances with partners with very different technological profiles (Noteboom *et al*. 2007). Global innovation networks are thus partially motivated by access to foreign competences and ideas that thrive in specific ecosystems. Similarly, start ups, which develop a very specific technology, play an important role in open innovation networks. They are often themselves very open to academic research and participate to the transfer of technology, either to the market if they grow and gain a large market share, or to more mature companies when they are acquired.

4.6 Policy implications and the contribution of ERA

The Lisbon strategy rightly aimed at stimulating knowledge-based growth in the EU. It combined an input based policy (increasing R&D investment) with an attention to demand through the achievement of the Single Market. The open innovation paradigm nevertheless implies that innovation processes are becoming more integrated. As a result, the contributions made by the different actors tend to be more specialised and interactions between actors become more crucial. In particular, high tech start ups, despite being small and few, can play a fundamental role in technology transfer, market development and growth. Similarly, technology transfer and public-private partnerships, while representing only a small share of R&D budgets, can constitute a major stimulus for various innovation types. In this perspective, policies that aim to stimulate an evolution of the sector composition of the European business will need to reflect and promote open innovation practices appropriate to that evolution.

The emergence of open innovation practices thus provides an opportunity to reconsider a number of national policies, including RTD policies, interaction-oriented policies, entrepreneurship policies, science policies, education policies, labour market policies and competition policies (De Jong *et al.* 2008). Global open innovation networks also call for a fresh look at attractiveness policies and at the role of knowledge circulation. For the EU level a number of recommendations follow from the above development three challenges relating to international and open innovation networks.

1. *The entrepreneurial challenge*

   Open innovation practices require variety in terms of small entrepreneurial activities and their avenues for growth, combined with the structures and activities of more established firms. The challenge is to put in place structures, networks and markets capable of supporting the development of such entrepreneurial activities, which are capable of challenging and also replacing incumbent large companies in dynamics markets, such as high tech and knowledge intensive service sectors.

2. *The ecosystem challenge*

   The need for more interconnectedness of actors, activities and knowledge implies corresponding complementarity among different actors, both public and private, as well as appropriate open innovation infrastructures. The challenge is to put in place the appropriate incentives and research soft infrastructures to enable the exploitation of complementarities and reduce transaction costs.

3. *The global connection challenge*

As innovation activities open up to the global economy, a primary challenge is to stimulate demand and develop local environments that are attractive to the players that perform these activities and deliver commensurate benefits to the community. Conversely, local companies, research institutions and cluster need to be efficiently connected to global networks, especially if they are at the frontier and aim at generating radical innovation.

This Chapter puts forward one policy principle and five policy recommendations that focus on the above challenges and the potential contribution of ERA to the successful application of open innovation practices in Europe. [84]

Design EU policies as direct instruments to stimulate research and innovation.

First, as a general principle, EU policies should be designed to have a direct impact on research and innovation performance, as opposed to the construction of ERA per se. Currently, most ERA initiatives are institutional in nature, and seem to take for granted that their successful implementation will eventually support the broader goals of the Lisbon strategy in today's context. A more explicit perspective is requested, which requires that policy makers fully understand what drives business R&D, how contemporary innovation processes operate, and where there are opportunities for the EU to gain a comparative advantage.

This change in focus has many implications, for example for the Co-operation programme within the Framework Programme. The new perspective could lead, for example, to a greater role for the ERC based on excellence through competition criteria; the promotion of young innovative companies and their growth at the EU level; full reflection on the role of EIT alongside JTIs, lead market initiatives, the Eureka programme, etc. Most of all, however, it points to the importance of effective policy integration beyond R&D.

Promote the evolution of EU specialisation through the growth of young innovative companies

There are many recent examples of radical and high-performing innovations on the market that have come from successful start-ups and also of the enhanced cross-fertilisation that is taking place among firms of different ages and sizes. [85] Yet many European countries have experienced limited growth of such young innovative companies, preventing these firms from taking a key role as an efficient channel for innovation and knowledge flows to the benefit of the entire eco-system. We refer to this as the EU's growth paradox. Since innovative start-ups are less tied down by costs that are sunk in established activity and tend to be more agile and flexible than large, already mature firms, they can, despite their limited size and number, be a source of new activities. Such firms therefore constitute a potentially very important avenue for the evolution of specialization and knowledge growth in any economy, including in Europe. Furthermore, because (as shown in Chapter 1) aggregate industrial R&D is currently concentrated within a small number of large firms, the failure to achieve widespread growth has contributed directly to the deficit in European business sector R&D.

[84] They are intended to be consistent with the findings of earlier expert groups, including the 2008 report on the rationales for the European Research Area (Georghiou, 2008).

[85] Apart from case studies and the transatlantic age differential of large innovative companies, Veugelers (2009) provides a statistical analysis in the case of Germany.

The challenge is therefore to put in place structures, networks and markets capable of supporting the development of such entrepreneurial activities. A range of measures need to be taken to underpin opportunity-based or knowledge-based entrepreneurship, which by definition hinges on the attitudes of individual human beings and the presence of arenas in which risk-taking, experimentation and intensive collaboration between complementary competencies are possibly (Andersson et al, 2009). Progress will also depend on local initiatives enabling improved knowledge and technology transfer, as well as on broader issues, including the promotion of demand for innovation, the relationships between large and small companies and standard IPR issues, such as the Community patent and a European litigation court. It is likely that such actions will not be the primary responsibilities of research ministries and DG Research, but their active support will be needed for such initiatives to be well-targeted and succeed.

SME-related policies in Europe have not been as successful as was hoped, for example when measured in terms of these firms' survival and growth compared to other parts of the world (Guellec and Sachwald, 2008). The difficulties faced by young innovative companies are largely due to characteristics of national economies. Nevertheless the Cooperation programme within the FP has not assisted in supporting these, but was instead targeted towards a particular level of participation by SMEs. A specific new EU instrument could be designed to support the growth of innovative start ups and their evolution. Veugelers (2009) has proposed such a new scheme, the characteristics of which could be elaborated and further specified.

Stimulate the development of open innovation (soft) infrastructures

The second challenge specified the need for more interconnectedness of actors, activities and knowledge implying complementarity among actors and open innovation infrastructures. The challenge is to put in place the appropriate incentives and research structures to enable the exploitation of complementarities. At the European level, one such structure could be the community patent, which should be complemented with European Patent Litigation Agreement (EPLA). The implementation of the community patent would be an important step to promote efficient open innovation practices but also to support the development of young innovative companies in the EU. Researchers' mobility (public-private, international) is another such soft infrastructure. The European Institute of Innovation and Technology (EIT) and its Knowledge and Innovation Communities provides a specific example of such mobility measures. A third structure would be to focus on stimulating knowledge and innovation intermediaries supporting the growth of markets for knowledge and technologies by matching ideas, knowledge, linkages and networks. Such a measure would therefore enable enhanced connectivity between small and large firms and between young and more established companies in international and open innovation networks emphasising the linking of complementary technologies and business opportunities.

Stimulate demand for innovation to increase ERA attractiveness

Companies' practices stress the importance of market demand in the organisation of the innovation chain as well as in the choice of location for R&D activities. In EU countries, companies' R&D activities will partly depend on the development perspectives of new markets, for example to face the challenges of ageing and environment: such markets must provide the prospect of sustainable profitability.

Debates on the stagnation of R&D intensity in Europe have suggested that production structures should evolve as the R&D spending of mature firms reflects the sectors in which they operate. Open innovation can, and does, challenge established companies' routines and thereby stimulate more radical developments which can permit entry into new markets. But the take-up of these developments depends also on having successful new and innovative firms, for which access to markets is vital and to a large extent comes from trading with other (larger) companies. A more integrated ERA and common EU market would contribute to a more dynamic growth of new firms within their global networks as well as the continued success at global level of established players. Lead markets are one example of instruments that could be at the intersection of ERA and the Single market. A specific instrument to stimulate demand for innovation is Pre-Commercial Procurement of R&D services, a very promising scheme that was modelled upon successful US examples and put forward by the Commission at the end of 2007[86].

Promote radical innovation and global connectedness

As discussed in this Chapter, open innovation tends to be global and vital for innovative performance. Empirical studies more specifically suggest that companies engaging in radical innovation processes tend to benefit more from alliances with partners with very different technological profiles, including foreign ones. Innovation intermediaries are important actors, particularly suitable for linking partners with complementary technologies. Global innovation networks are thus partially motivated by access to foreign competences and ideas that thrive in specific ecosystems. ERA should thus promote connection with and participation in global networks in order to stimulate radical innovation.

A specific open innovation instrument should be designed to promote radical innovation and anchor global networks of innovation nodes in ERA. Such an instrument would spur partnerships on a European scale and on the basis of their potential for radical innovation. It would be based on the "excellence through competition" promoted by this report and would impose no geographical conditionality. In particular, the scheme could fund projects involving non-EU partners, especially in cases where global connectedness is necessary to stay at the frontier and help generate radical innovation.

4.7 Conclusion: complete and rationalise the ERA policy mix

The dynamics of open innovation networks defines the extent to which companies will seek co-operations, engage in identifying the right partners, and finding the adequate forms of collaboration for each of their objectives. This Chapter has, for example, discussed the case of university-industry collaborations and analysed their determinants: companies engage spontaneously in extensive collaborations because they have ambitious innovation projects that demand specific intellectual input. When companies identify a strategic partnership, they tend to seek an agreement, even if the partner is geographically distant and if there is no public funding.

The empirical studies available on the determinants of the different types of collaborations can be used to revise the objectives and instruments of the Framework Programme, in the ways suggested by the Ex-Post Evaluation of FP6 (EU 2009a), which proposes greater strategic focus with fewer, managerially compatible objectives. This chapter has in particular proposed the design of two schemes to address the challenges of global open innovation.

This perspective can also guide the future development of the EU's State Aid Rules and related regulations: to foster university-industry collaborations, to provide straightforward operational guidelines that explain when restrictions apply and to aim for the minimum restrictions necessary consistent with broader policy objectives.

Overall, the range of instruments used by the Commission and others seems unmanageable and often unclear to the intended beneficiaries. A general table is required of the ERA instruments,

[86] See http://cordis.europa.eu/fp7/ict/pcp/home_en.html and Chapter 2 on Societal Challenges.

expressing their objectives and assessing their performance. It is not possible to express the eventual desired balance between different mechanisms in place to support research, between funding and non-funding instruments at one level and between mechanisms such as 171s, 169s, Joint Programmes, and the finer details of new PPPs, KICS, and the ERC. This will emerge when proper instruments are devised for creating true PPPs and for achieving an effective variable-geometry ERA. A judgment can then be made of which approaches are working well and which are not.

Considerable impact may be achieved by focusing on a few key areas. Such areas include improving the possibility for actors to collaborate according to the different logic of their situations; improving the attractiveness of local environments within the EU in support of innovation-oriented goals; addressing the excellence of public research infrastructures; identifying the strategic priorities for R&D and innovation in EU; and improving the connection between R&D, innovation and other public policy priorities, aiming always for simplicity and risk-tolerance.

There are some inherent differences in emphasis and potential contradictions, which need to be recognised and accommodated. For example, open science concentrates on the free flow of knowledge within a global community, without too much consideration given to the economic implications, while open innovation is driven primarily by the possibility to gain benefits that will be economic in nature, if not in their articulation. The ability to resolve such differences within public policy will depend largely upon the responsible authorities' ability to provide leadership and take a holistic approach to government (Mulgan, 2009). The effectiveness of local, national and regional policies is likely to change as innovation practices become more global and connected, and policy development will partly depend upon having appropriate supporting metrics.[87]

[87] There is evidence that current metrics are inadequate for this task (e.g., EU 2007b and the OECD "Blue Sky" initiative).

Chapter 5:

Regionalisation and the future of European research policy

5.1 Introduction: Regional disparities: a problem for research and innovation policies

After a long period of incubation, the European Union has adopted the notion of merit-based and grant-based competition for funding by creating the European Research Council as an independent entity and protecting it from considerations of national share and fair return. This is an enormously important achievement, one that corrects the previous policy orientation entirely based on networks and addresses some of the most relevant weaknesses of the European scientific system. The recent institution-building activity at European level is extremely encouraging[88]. It is important to continue along these lines, by keeping the political consensus high and by maximizing the impact of new merit-based institutions supporting research and innovation.

However, the spatial concentration of innovative activities creates an important issue for EU research and innovation policies to address. At European level, the large regional disparities in innovation potential do not seem to reduce over time. Such disparities represent a problem not only for cohesion policy, but for innovation policy itself. Successful innovation can reinforce, rather than counterbalance, a core-periphery hierarchical structure of territories. Cumulativeness and path dependency can easily dominate over the catching up and entry of peripheral territories.

If innovation inevitably follows a natural pattern of concentration, and if competing on a world basis implies the need for excellence, then it will be important to reward excellence at European level, whatever the geographic origin. However, a number of government policies, including public procurement as well as some research and innovation policies actually counter, rather than improve, opportunities for decentralisation and spatial diversification. Unless such factors are addressed, laggard regions may argue that playing the excellence game is unfair, because the playing field is not being levelled, and that allocating resources to pure merit-based competition means fostering the capabilities of those regions that not only are already strong, but also beneficiaries of unfair advantages.

Faced with such issues, there have been at least three main reactions:

- a position that considers that less developed countries and regions will benefit from increased quality of the overall European research system, following some unspecified spill-over effect[89];
- a position that underlines the potential for enhanced diversification and specialisation given that research and innovation policies become more conducive to autonomy and tailoring of growth strategies to local conditions;
- a more critical position that considers that some counterbalance must be put in place so that there must be adequate cooperation between European research and cohesion policies.

[88] On the relative role of policies and institution-building see Bonaccorsi (2007); on the poor performance of European science see Institutions vs policies. *Science and Public Policy*, 303-316.

[89] For example, the per-capita distribution of ERC grants by nationality is much flatter than the distribution of the institutes where the grant recipients then work. Unfortunately, this observation does not guarantee that there will be subsequent spillover benefits in both directions.

In this report we have already noted the potential contributions of policies in line with the second of these positions. In addition, we subscribe to the third position and try to articulate carefully how it may be achieved.

5.2 Institutional path dependency and the persistence of disparities: The case of Eastern European countries

Regional disparities are particularly strong and persistent in the New Member States in Eastern Europe. It is useful to focus on these countries, not because other underdeveloped regions are less important, but because it highlights some stringent lessons for research policies that require urgent attention. Possibly, not enough time has passed since joining the EU for these NMS to have gained full benefits in the fields of research and innovation policy. However, it is also possible that they are experiencing the rapid and unintended consequences of policies outside the original goals. Such consequences must be understood and where possible corrected.

A number of structural factors may explain the persistent disparities[90]:

(a) Traditionally, many of the NMS have had a high level of tertiary education, sometimes with peaks of participation rates for doctoral degrees.

The availability of highly-qualified human capital would seem to provide an ideal pre-condition for supporting a rapid catching up effort. Paradoxically, this is not necessarily the case. In the absence of adequate local infrastructure and capital investment, young talented students may be attracted by multinational companies that can offer superior wages and relocate them to another country, or may prefer to be hired by foreign scientific institutions and universities, also because the local research system is uncompetitive in terms of salary and careers. Because of this, brain drain can still be a major impediment to growth.

(b) These countries have had a prestigious tradition of public investment into fundamental scientific research, mostly organized in centralized institutions (Academy of Science). This means that there exists a population of scientists and researchers that are active, prestigious and internationally recognized. Under these conditions, it is possible that national priorities in research and innovation have been driven directly by academia rather than by industrial or national objectives, thereby tending towards a priority agenda that reflects excellence in scientific activity, not necessarily long term growth potential of the economy.

What happens may be similar to the “regulator capture” in industrial markets: those that are subject to the policy are those that write it.

(c) On top of these structural conditions, the Europeanization trend in research means that the most productive scientists from NMS are being drawn into networks at European level. They become more and more “European”, receive additional funds, and leverage on initial money to build up long term capabilities for fund raising at European level.

This happens in a context where the bulk of the research system is heavily influenced, in terms of resources and goals, by the national environment. The separation between the internationalized part of the scientific sector and the inward-looking part may become dangerous.

[90] It is worth recording that negative outcomes are not inevitable, and that there are regions within the NMS which do have relatively strong industrial bases and excellent connections between government, academia and industry.

(d) Because of the long-term absence of these countries from competitive international capitalism, there may be a lack of skilled people who understand how to operate in the global economy except on a basis of low costs. This creates a vicious cycle of low investment, poor wages, reduced attractiveness and further decline in competitiveness.

This situation will persist until substantive efforts are made to improve the competitive performance of the industrial system. This will not be achieved solely by investing primarily in national science, but in general levels of education and training and capital infrastructures.

(e) The final outcome of these structural conditions is to create a deep separation between the research system and the manufacturing and tertiary structure of the country. They have different priorities and divergent goals, and the dialogue is problematic. Consequently, there is still lock-in of resources that are stuck with low productivity levels over extended periods of time. A new dynamic is required, perhaps along the lines described by Saxenian (2006), which fosters brain circulation and reinvestment.

Let us review these factors in more detail and consider where and how it may possible to overcome them.

Optimal funding

Regardless of whether the objective is to foster excellence or cohesion, the current allocation of research funding in many parts of Europe is sub-optimal. Strict control of funding by national research agencies and an aversion to competitive project funding has produced a lack of competitiveness and sub-optimal funding at project and team level and unwarranted duplication of effort at the system level.

The 2008 ERA Rationales report described the consequences mainly in terms of sub-criticality at the institutional level: a reduced inability to handle inter-disciplinary studies well; lack of economies of scale that could be gained by sharing expensive equipment; inability to configure teams from a range of capabilities leading to reduced industrial interest in collaboration and higher overhead costs; and, perhaps most seriously, reduced flexibility to cope with shifts in funding patterns from one field to another. Such issues exacerbate the path dependencies that have given rise to regional disparities.

Realizing a more effective market for research funding is a long term goal for Europe. Partial achievements have been realized through the Open Method of Coordination approach (OMC)[91], particularly with ERA-Net and ERA-Net+ schemes and through bilateral and multilateral agreements between research funding agencies. A further impact is expected as the European Research Council develops, with national governments joining the efforts using the ERC approach to enlarge the pool of competing researchers. The notion of Fifth freedom is very important here. But much less has been attempted or achieved in areas where the concept of a single market would make most sense: the funding and organisation of applied research, primarily carried out by RTOs.

The strategic move towards a European level for funding of fundamental and applied research on the basis of pure merit, without any national quotas, is to be confirmed and reinforced. The key is not to add another source of funding, but to change structurally the funding system of public research by pushing towards the creation of a large, competitive and transparent funding pool at European level. The positive effects may be slow to materialize but in the medium to long term, this

[91] See Appendix 5.1.

will benefit those national systems that are willing and able to undertake appropriate parallel reforms.

Mobility of researchers

Achieving full mobility of researchers is one of the primary objectives of the European Research Area, because this will improve knowledge exchange and thereby lead to a thicker and richer job market. Mobility is also necessary for junior researchers from less well-resourced countries who wish to pursue state-of-the-art opportunities but currently work in environments that cannot attract a sufficient diversity of skills and resources.

Regional disparities tend to exacerbate the unbalanced patterns of brain drain. Countries may have a pool of talented undergraduate and postgraduate students to whom they cannot offer career and wage prospects that are reasonably competitive with other European countries. For them, entering into the European Research Area without a counterbalance policy may worsen the situation, with movement of researchers to international centres of excellences being seen to reduce local capacity by more than it raises the overall capacity. Furthermore, the resulting human capital impoverishment of cohesion regions can reduce their capacity to modernize by depriving potential researchers of a place to return to.

It is possible to anticipate that some countries and regions with a negative brain drain may withdraw political support to European policies aimed at fostering mobility of researchers. In large countries (such as USA) that share a common national identity, where responsibility for research is mainly federal and where there has been sufficient time for the system to equilibrate, flows of people across states or regions are less of a political problem than in Europe. Yet, we can start to see evidence that China is starting to suffer a backlash as a consequence of its centralised policies.

The implications are that policies aimed at encouraging international mobility require also a widespread belief, which can only partly be sustained by strong evidence, that the "European project" is worthwhile and mutually beneficial, and by parallel efforts to invigorate all regions according to local interests, strengths and priorities.

General levels of education and training

While there is a problem at the top of the skill hierarchy, NMS also start to suffer from inadequate investment into mass education at all levels. High quality education, particularly in terms of cognitive skills, is essential for building the absorptive and innovation capacity of NMS. The OECD PISA results indicate that the situation in the majority of NMS in this respect is far from satisfactory. There is a need to ensure stricter teaching standards and to introduce staff appraisals at all levels in the system. Education systems should support creativity by increasing levels of specialisation late in school careers and abandoning the culture of mechanistic and repetitive learning. In addition, it is essential to reconcile quality and equity of education. The example of Estonia confirms that this is possible to achieve in NMS. However, higher quality is unlikely without increased investment. The evidence suggests that expenditure on education in the Central and Eastern European Countries (CEECs) is associated with improved quality of education. Most of the NMS spend less per student than the OECD average. Improvements are required at all levels of education and should not be made at the expense of other levels.

The wider problem of skills mismatch in the labour market is not unique to the NMS, but is a major structural problem for them. The need to invest more in lifelong learning and retraining to help workers and firms to continually upgrade their skills is not yet a national priority in NMS and should be given much more prominence. The evidence suggests that providing tax incentives for workers and firms to take up training opportunities is more fruitful than attempts to set up publicly-managed training programmes. The current global financial crisis should not be used as an excuse for reducing funding for education and training.

Priority setting

R&D systems in NMS are currently caught up in a strong process of "Europeanization". The dynamics of EU RTD policy have become a part of the organizational logic of national S&T and innovation policies. However, this may lead to the mechanical transfer of policy models that may not be the most relevant for their priorities. The strongest effects of Europeanization in the southern EU countries were on the definition of relevant policy actions and mechanisms and of national priorities. There is no reason to believe that the outcome will be any different for the NMS, and this may lead to a strong policy myopia in which the importance of local R&D issues, the existence of local strengths and the search for local solutions are ignored. Excessive reliance on the EU policy shelf and ignorance of local issues risks reducing the pressures to develop policy as a 'discovery process' carried out in support of local interests.

Europeanization of the research system

A common feature in most of the NMS is that improvements in their national innovation systems (NIS) are considered largely in the context of research (rather than innovation) and reflected in publishing activities (rather than economic growth). This trend is likely to strengthen through the Europeanization of their R&D systems, which will plug these countries' research efforts into the best EU R&D groups and networks. We can expect improvements in terms of a better balance between incentives (selection through project funding) and stability (share of institutional funding). However, the bottleneck – weak domestic demand for R&D and a weak business enterprise sector (BES) able to capitalize upon the resources available – is likely to remain a major structural weakness.

Overall, improvements in NMS have been made by introducing peer-review based funding mechanisms that are geared towards scientific excellence. However, the exclusive use of excellence criteria may actually 'freeze' science specialisation. Funding systems are still inadequate in terms of ensuring industry and social relevance. This would require a much stronger involvement of users in evaluation and funding, and better policies for developing applied research institutions and RTOs.

Crucially important, moreover, is that the distribution of funds needs to be designed so as to appreciate pluralism, niche-strategies, development potential and renewal. Resources are not to flow in a uni-dimensional manner to what is already established, thereby concentrating on past excellence rather than future needs. Inherent here is the difficulties faced by an established scientific community in appreciating what may come ahead.

However, these effects by themselves will not ensure the relevance of these countries' R&D systems to their local economies. As the best R&D groups become integrated into EU networks, the gap between them and the local business sectors may widen. The situation of NMS may resemble the situation in Greece where a competent R&D system has relatively limited links to the domestic business sector. It is essential that the EU and NMS analyse how to avoid replication and multiplication of the Greek scenario to NMS.

The weakness of horizontal linkages

Two major channels of knowledge inflow in NMS are in upstream areas of R&D through the Framework Programme and in downstream areas through knowledge transfer via foreign direct investment (FDI) and industrial networks.

So far, FDI and industrial networks have provided the main channels for productivity improvements and knowledge inflows in NMS. Econometric research on FDI in NMS points to the importance of vertical backward linkages as the major channel for positive spillovers and the relative weaknesses of horizontal linkages resulting in non-existent or negative horizontal spillovers. In upstream areas, the NMS are either already integrated into the EU R&D system through research networks (Slovenia, Estonia) or are on the way to be integrated through their participation in EU R&D programmes (Romania, Poland). This increases competition, funding, and the attractiveness and excellence of their R&D systems. However, integration of the NMS through vertical R&D and FDI knowledge flows may lead to fragmentation of their innovation system (Figure 5.1).

Figure 5.1 Vertical R&D and FDI knowledge flows in NMS

Outcome
- Vertical integration; horizontal fragmentation

Policy focus
- Support to the weakest agent: local business R&D
- Transfer function on supply side (R&D)
- Transfer function on demand side (FDI/local firms)

The major channels for improvements in NIS should be horizontal linkages between public R&D (supply side) and FDI with domestic suppliers and buyers (demand side). (Horizontal) linkages between the supply and demand sides of R&D are important for building the national innovation system (NSI).

A strong local business enterprise sector is the key actor in coupling demand and supply of R&D, and its international integration. The paucity of BES R&D and its weak links to domestic sources of knowledge is at the heart of the weak innovation systems in the NMS. Furthermore, a conscious policy of building EU centres of excellence in NMS may not necessarily lead to positive outcomes but could instead crowd out spontaneous innovation activities.

Summing up

Summing up, it is unlikely that ERA can, in itself, produce beneficial effects in all regions. Positive local effects are not guaranteed, due to strong interdependencies between places and other direct and indirect effects. The underlying principle of ERA - Fifth freedom – will be "spatially-blind" unless it accounts for local efficiency effects in individual member states. Ignoring these local effects can lead to a number of unintended negative consequences, including *local irrelevance*: investment may be favoured in activities which are inappropriate and not in line with either actual or potential comparative advantage of regions/places. This trade off between excellence and cohesion is context specific and can be only addressed by taking local relevance into account.

Recently a number of high-level concepts have been introduced or rediscovered in the policy debate at European level, which are extremely relevant in order to design a better policy trade-off. They are:

- place-based policies
- smart specialization
- conditionality.

We review them in turn and try to derive a number of implications at the end of this Chapter.

5.3 Combining merit-based and place-based policies

The Barca report (2009)[92] sees innovation as one of core priorities within its place-based approach to EU cohesion. Place-based interventions are proposed as complementary to developing a European Research Area, by selecting in each region a limited number of sectors in which innovation can most readily occur and a knowledge base built up.

The Report argues that policy effectiveness has been achieved '*when cohesion policy has been implemented as a coherent part of a national development strategy* (p. 106). Indeed, this is quite compatible to historical experience that growth and catching up is usually complement between national development strategy and foreign knowledge imported in different forms (FDI, capital equipment, skills flows, trade, etc). The novelty of the Barca Report approach is that it recognises the limits of an endogenous only approach to development. The argument is that the massive injections of EU funds in regional knowledge economies are not nearly enough by themselves, but could even be detrimental. For example, it observes serious limitations to actions like RIS.

'For whatever reason, the interventions in this area in the 2000-2006 programming period have not lived up the expectations. The capacity to build, place by place, a policy tailored to regional innovative potential was often inadequate. Efforts to improve policy-making, strategy development and evaluation, including coordination between national and regional policy-making, were limited. Financial allocations to innovation planned in 2000 had to be reduced at the mid-term point in several Member States due to implementation difficulties arising from the design of the new measures and the weak demand from enterprises' (Barca, 2009, p. 311).

Instead, Barca (2009) pleads for combined exogenous and endogenous push. The report sees the main purpose of cohesion policy not in redistribution but to trigger institutional change and to break inefficiencies and social exclusion traps through the provision of public goods and services. (p. xiii). This triggering of institutional change can come only through 'an exogenous public

[92] Barca (2009) *An Agenda For a Reformed Cohesion Policy. A place-based approach to meeting European Union challenges and expectations.* Independent Report prepared at the request of Danuta Hübner, Commissioner for Regional Policy by Fabrizio Barca, April 2009

intervention (which) can improve things by upsetting the existing balance. But for this intervention to be effective, it needs to be accompanied by increased local involvement. 'This is the condition for eliciting the information on preferences and the local knowledge needed to tailor interventions to places and to reap the advantages of closer citizen control' (p. 40).

Sufficient local involvement can only be achieved though locally relevant activities. For example, the New Member States need to find ways of increasing the industrial relevance of their science base by linking Centres of excellence in science to areas of industrial strength. In addition, policies need to differentiate between research and non-research based activities as the latter are quite relevant for catching up countries. In general, there is very little implementation of policies that differentiate in any operational way between non-research-based activities that lead to innovation, and research based activities – in particular R&D – that do lead to innovation (EW, 2006)[93].

A further integration of domestic R&D into the EU R&D networks will lead to an improved R&D system in terms of quality and international excellence, but not necessarily in terms of local relevance. (In fact, the gap between supply and demand in terms of local R&D may widen.) However, we can expect that NMS' R&D systems will be highly integrated into the ERA. This should have positive effects in terms of dynamism and excellence in R&D, as many countries' R&D groups will be 'plugged' into the EU R&D networks. In the long-term this should have similarly positive effects on education systems through the reorganization of universities, and increased R&D levels which in turn should lead to higher quality teaching. The Expert Group's main argument is that such gains can only be achieved through policies that extend far beyond ERA.

5.4 (Smart) specialization

The expert group on *Knowledge for growth* chaired by Dominique Foray has raised the attention on the lack of specialisation at national and regional level as an important factor, launching the notion of "smart specialisation" (Foray, 2008; David, Foray and Hall, 2009). The argument goes as follows: if all countries and regions in Europe fight to reach the frontier of science and innovation, the majority will miss the goal. To reach the frontier there are extremely severe conditions in terms of scale, scope and critical mass. As an example, only four US universities account for 15% of the overall career mobility of top worldwide 1000 scientists in computer science.

For countries, regions and institutions that cannot play this game, it would be better to search for a suitable specialisation in the global competitive landscape. It is most likely that this specialisation will take place along applications, exploiting business segments, niches, or markets that require adaptation of general technologies to specific user needs.

The specific properties of *General Purpose Technologies* (GPTs) define a framework that helps to clarify the logic of Smart Specialisation (SS). While major innovations often result from the commercialization of a core GPT invention, and its successive technological elaborations – such as the double-condensing steam engine, the electric dynamo, the internal combustion engine, or the micro-processor, there myriads of economically important innovations that result from the « co-invention » of applications (steam-ships and locomotives, arc-lamps and AC motors, etc.) In fact, the characteristics of a GPT are horizontal propagation throughout the economy and

[93] EW (2006) Technical Report concerning information collection and analysis on R&D specialisation in Europe For the Specific Contract: Future data requirements of the ERAWATCH Baseload inventory: Feasibility study on R&D specialisation. Submitted to the IPTS by the ERAWATCH NETWORK ASBL, Prepared by: Joanneum Research, Logotech, NIFU-STEP, SPRU – University of Sussex, ISI Fraunhofer, Vol 1, Brussels, October 2006

complementarity between invention and application development. Expressed in the words of an economist, invention of a GPT extends the frontier of invention possibilities for the whole economy, while application development changes the production function of a particular sector. The basic inventions generate new opportunities for developing applications in particular sectors. Reciprocally, application co-invention increases the size of the general technology market and improves the economic return on invention activities relating to it. There are therefore dynamic feedback loops in accordance with which inventions give rise to the co-invention of applications, which in their turn increase the return on subsequent inventions. When things evolve favourably, a long-term dynamic develops, consisting of large-scale investments in research and innovation whose social and private marginal rates of return attain high levels. *This dynamic may be spatially distributed between regions specialised in the basic inventions and regions investing in specific application domains.*

This framework suggests strategies that can be pursued with advantage both by regions that are at the scientific and technological frontier, and by those that are less advanced. While the *leader regions*[94] invest in the invention of a General Purpose technology (GPT) or the combination of different GPTs (bioinformatics), *follower regions* often are better advised to invest in the « *co-invention of applications* » - that is – the development of the applications of a GPT in one or several important domains of the regional economy. Some examples would be biotechnology applied to the exploitation of maritime resources; nanotechnology applied to the wine quality control, fishing, cheese and olive oil industries; information technology applied to the management of knowledge about and the maintenance of archaeological and historical patrimonies. By so doing, the follower regions and the firms within them become part of a realistic and practicable competitive environment -- defining an arena of competition in which the players are more symmetrically endowed, and a viable market niche can be created that will not be quickly exposed to the entry of larger external competitors. The human capacities and resources formed by the region, thanks in particular to its higher education, professional training and research programmes, will constitute « co-specialised assets » – in other words the regions and their assets have mutual needs and attraction for one other – which accordingly reduces the risk of seeing these resources go elsewhere.

Using the GPT framework, we hope to make clear that smart specialization should not be associated with a strategy of specialization of region X for instance in tourism. What smart specialisation suggests for region X is to specialize in the co-invention of ICTs application in the sector of tourism, for instance to improve the quality of some services. Smart specialization deals *with R&D and innovation* specialisation.

Experts and policy makers are increasingly thinking that the question of "how to specialize or what specialization (for this country or this region)?" relevancies becoming more relevant as the European Research Area is advancing, particularly in those regions/countries that are not leading in any science and technology fields. These regions/countries have in any case to increase their intensity of knowledge investments and intangible capital in the form of high education and vocational training, public and private R&D, other innovation activities assets. The question is whether there is something better to do than investing a bit in biotechnology, a bit in information technology, a bit in nanotechnology. Is there not a better strategy for them than being subcritical and inefficient in allocating resources to those fields in which they will always be laggards? So a

[94] In the Knowledge for Growth contributions, a distinction is drawn between "leader regions" that master the technological frontier, follower regions that are able to catch up to a leader region and laggards who struggle to build up absorptive capacities to apply advanced technologies (see Policy Brief N° 5 on catching-up countries).

policy question of great relevance for any (or almost any) region/country in Europe is now: how should it position itself in the knowledge economy?

For Europe, with its multitude of still highly fragmented layers of governance and sub-critical institutions, it will be crucial that the ongoing process of knowledge accumulation leads to regional smart specialization, a process which avoids the problems of "locational tournament" competition amongst regions in developing many, similar knowledge peaks. At the same time, the basis of such regional peaks should be sufficiently large and locally "deeply" integrated (Veugelers and Mrak, 2009). Smart specialization, which is an entrepreneurial and decentralized process of search and discovery, is considered as a conceptual response to this challenge. In this entrepreneurial process the new knowledge produced is closely linked to the particular specialisations of a region. Therefore the social value is high as the new knowledge generation is intended to guide the development of that region's economy.

One of rationales for the ERA is that it should avoid unwarranted duplication of research, and instead aim to achieve economies of scale and regional specialization. The EW (2006) report on R&D specialization points out that duplication becomes a problem 'when there is a massive duplication of research efforts often followed by non-original research which neither contributes to the advancement of the frontiers of knowledge organically nor serves any particular regional or national innovation needs. Such research does not contribute to national or regional absorptive capacity; neither does it advance the S&T frontier'. So, the real issue is not duplication as such but whether activities are of sufficient quality and local relevance. If research was at the world level of quality, duplication would simply reflect a diversity of approaches. Instead, when the research is of mediocre quality and locally irrelevant, it becomes redundant.

However, before we address the issue of specialization (or the lack thereof, i.e. duplication) it is necessary to establish whether there is actually a lack of specialization in R&D in EU. We draw on the EW (2006) report which is the first (though still pilot) systematic effort to look at this issue across the EU. Major stylized facts which emerge from this preliminary work are:

- There is not a lack of specialization of R&D profiles in EU27. Overall, there is a great deal of differentiation amongst the EU countries in terms of their R&D specialisation profiles[95].
- Countries tend to be more specialised in terms of technology and economy than in terms of science. The scientific profiles of the three regions – the EU-15, Japan and the USA – are more homogeneous (with fewer specialisation areas) compared to BERD specialisation.
- The real issue seem to be not lack of specialization, but lack of links between economic and science specialization. For example, the BERD specialisation profile in the EU-15 is correlated neither with value-added nor with employment specialisation profiles. Conversely, the USA specialisation profile is strongly and positively correlated both with value-added and employment specialisation profiles.
- The striking pattern is the lack of parallelism between public and private sectors so far as the structure of the respective knowledge bases are concerned. However, this may be a mirage, as public R&D organisations 'may be more geared to scientific ways of structuring content, based on academic disciplines while firms in the private sector, on the other hand, structure themselves according to the pattern of industry and consumer demands, which may constitute quite a different structural 'map' (EW, 2006).
- There is not lack of specialization in terms of BERD specialization profiles in EU. Overall, there are large differences between the EU countries in terms of business R&D

[95] For example, only 22 of a possible 171 correlations (13%) of pairs of countries are positive and statistically significant; a further 10 are negative and significant.

specialisation profiles. The EU countries business R&D specialisation profiles are more varied than their profiles in terms of economic, technological and scientific specialisations.
- A variation in business R&D is largely due to differences in many non-manufacturing sectors like mining, retail/wholesale trade, R&D services telecommunications services and agriculture than manufacturing sectors. In contrast, many of the manufacturing sectors display the same level of variation in both economic and R&D specialisations.

One of conclusions of this report is that policy makers should pay more attention to how and why BERD is so weakly correlated with economic specialisation and how this relates to activities in their public R&D bases. For example, 'the comparison of Estonian and Finnish wood sectors reveals that in Estonia the public R&D base is extremely weak and not aligned with the sectors under discussion. While the absorptive capacities of firms in Estonian wood sectors are increasing, the lack of relevant domestic research institutions may become an impediment to the future development of the wood sector as a whole. Additionally, public measures for domestic IT and biotechnology sectors to specialise in wood-related technologies would be desirable' (EW, 2006).

The issue of specialization is often reduced to the choice between high or low tech. A policy issue has been defined as a choice of the EU between focus on high-technology and science-based industries as drivers of growth and employment problems, or whether it should look to the growth prospects within the low-tech and medium–low-tech industries on which the European economy is actually based. An important result of the PILOT project is the recognition that the policy issue is not a choice between these apparent alternatives as low and medium tech sectors are significant users of the output from high-tech sectors (Robertson and Patel 2007). The PILOT project has showed that *knowledge generation appears throughout the industrial system independently of the high-tech sectors. (…) technology flows are complex and the tendency for policy-makers to focus on flows within the high-tech sector are seriously misjudged (…) These findings underpin the basic argument of the study, that technology flows are complex and the tendency for policy-makers to focus on flows within the high-tech sector are seriously misjudged* (EW, 2006).

The idea of smart specialization has already been developed in policy studies although under different labels[96]. One alternative label is 'new industrial policy' which has been developed by the World Bank Institute group to formulate policies for technology catch-up taking into account the latest understanding of the nature of knowledge, technology and growth[97]. The key features of this approach are that[98]:
- industrial policy is a process for fostering restructuring and technological dynamism. It offers solutions that go beyond the traditional focus on background conditions and improvements in the investment climate;
- from an innovation perspective, it is important to understand the policy implications of a 'binding constraints' view of economic growth[99];
- policy should rely on the 'islands of excellence' that exist in (almost) every country to reform less successful areas;
- unlike the old 'picking winners' industrial policy, the key assumption in the new industrial policy is that no one, government included, can have a panoramic view of the economy—all views are necessarily partial;

[96] This section draws also on Radosevic (2009).
[97] For the purposes of this report we consider differences between concepts of industrial and innovation policy to be non-significant.
[98] http://go.worldbank.org/BVKEUGB840.
[99] The 'binding constraints' view of growth is an idea of Rodrik's, which was fully taken on board in the World Bank (2005) study. This is a targeted approach which requires an in-depth understanding of country specificities, rather than the application of best practice solutions.

- mechanisms for creating new opportunities are search networks—private-public partnerships and programmes that should bring together the better performing segments of the public sector and the better performing segments of the productive sector in an attempt to relax and unblock binding constraints;
- the focus of policy is on missing connections, which, when established, should have synergistic and increasing effects[100].

This new perspective recognizes that growth constraints are never general and generic, but are most often specific. This thinking resonates very well with the Barca Report (2009) which argues that *'design of integrated interventions must be tailored to places, since it largely depends on the knowledge and preferences of people living in it* (p. 6).

5.5 Conditionality

Clearly, if binding constraints are local and require a specific approach, the policy must focus on local knowledge. A key objective of this process is to identify constraints and establishing mechanisms for overcoming them.

The Barca report (2009) argues that 'the place-based concept does not assume that the exogenous State knows better. Instead, it allows for information being incomplete and designs a method for reducing the degree of incompleteness. It requires local knowledge to be "elicited and aggregated" and then combined with global knowledge (the routines and engineering know-how embodied in the provision of any public good or service). (..) in order to get local actors to reveal information and their preferences (regardless of whether they are members of the elite or not), the exogenous intervention must encourage their active involvement'.

Going into more detail of how such an approach could work, we firstly note that a major implication is that the actual implementation is more critical than ex ante rational design of policies. Because of the need to learn from specific and local conditions "there is a strong element of *indeterminacy* in strategic policies, by definition, in contrast to market failure policies which, ideally, should be able to calculate the welfare effects of each intervention. As the outcome is not known in advance - only the strategic objectives - the implementation is more important than the initial design. The policy process becomes a learning activity in itself" (Radosevic, 1997: 192). An alternative is to go beyond the old 'picking winners' industrial policy by focusing on an entrepreneurial and decentralized process of search and discovery, which is compatible with the idea of research and innovation networks - private-public partnerships and programmes that should bring together the public and private sector in attempt to discover economically attractive specializations. When industrial policy is approached as a process, what matters much more is the establishment of 'search networks', i.e. cooperative public and private sector efforts that anticipate technological change and its effects rather then *a priori* defined targets (Sabel, 2005; Wilson and Furtado, 2006; Kuznetsov and Sabel, 2006). It is more important to ensure the ability to learn from mistakes than to design policies that try to avoid any mistakes.

Secondly, there is prioritising of the institutional basis of industrial (innovation) policy over specific interventions. This idea is related to Peter Evans' (1995) idea of 'embedded autonomy'. Evans points to a paradox between autonomy and embeddedness which the State must resolve. State autonomy is necessary, but not sufficient. It needs to be complemented by an intimate understanding of specific industry situations, which is possible only through close links with

[100] In that respect, the New Industrial Policy is quite similar to the so-called second generation innovation policies (see EU, 2002).

business. Successful developmental States have managed to establish close ties and networks with the agents of modernization while at the same time retaining their autonomy, i.e. the capacity to avoid State capture.

Third, these policy goals are better implemented if the principle of conditionality is adopted on a large scale. By conditionality we mean a policy framework and several policy tools that make financial support from the European Union conditional on a number of achievements on the part of those receiving the resources.[101] The basic idea is that, in order to build on learning about local conditions for growth, it is essential that actors share the risk of policies. Research and innovation policies are by nature subject to uncertainty and risk. Actors accumulate learning and local expertise, but this can result in information asymmetries with respect to policy makers, that can be exploited to carry out inefficient policies or to benefit from rents. Policy makers can overcome this situation by defining policies not on overall goals, but by conditioning funding on intermediate or final outcomes. In doing so, a policy maker provides strong incentives to those actors that have the best available knowledge on how to reach results, while discouraging opportunism and rent extraction. In this way the burden of risk is placed on the shoulders of those that have the best local knowledge, combined with the best global or "engineering" knowledge on implementation of policies.

Conditionality exists on two main levels: macro-level and micro-level.

At macro-level the European Commission might apply conditionality in the planning phase, in the relations with national and regional governments over Structural Funds. The object of conditionality should be focused on specialisation. Countries and regions should give evidence of a strategic process in which they have the ability to identify areas in which the goal to compete at international level is realistic and feasible, although with risks.

At micro-level national and regional governments may apply extensively policy tools based on conditionality on intermediate and final results. This means:

- for those innovation processes for which there is a state of the art in international practice, so that the main activities and skills are well known and somewhat standardized, apply complete contracting strategies, e.g. conditionality of financial support on output indicators;
- for those research and innovation activities for which uncertainty precludes complete contracting, adopt a two-stage policy, as follows: (a) in stage I there must be an open call in which actors self-select projects and define autonomously intermediate results to be monitored in due time; (b) in stage II projects are selected and funded, but subsequent funding is conditional on the achievement of intermediate results commonly agreed, as monitored by independent parties;
- in the latter case, leave open the room for renegotiation of contracts, but subject to third-party monitoring, in order to define flexibly the adaptations needed.

Conditionality is a powerful tool for supporting policy learning because it helps to build up the causal relations that can be replicated, taking into account all differences in context. This is particularly true at the micro-level.

[101] The idea of conditionality is traces its origin to the idea of performance requirements as exemplified in development economics through analysis of Korean industrial policy by Chang (1993) and by World Bank in its *East Asian Miracle* study (1993). At the European level it has been taken on board by the Barca Report on the basis of a contribution by Bonaccorsi (2009).

5.6 The role of relevant knowledge

The Framework Programme's focus on research and on its intermediate outputs (designs, pilots) without sufficient attention on how to get the results implemented may lead to new gaps. The structuring effect of the ERA will be the biggest in NMS. As discussed in this Chapter, while this can have very positive effects, there are also likely to be negative effects for which there need to be counteracting policies in place. Such policies should firstly prioritise locally relevant but internationally excellent R&D (Table 5.1). As this may not be possible in many areas, NMS would then tend to give priority to the second best area, to islands of excellence but locally not necessarily relevant research. Areas that are locally relevant but are of poor international quality constitute cases of 'policy myopia', i.e. opportunities for comparative advantage which are not addressed by policy.

	Locally relevant	**Locally irrelevant**
Excellence	(1) First best/ Virtuous cycle	(2) Second best/ Islands of excellence but not relevant locally
Non-excellence	(3) Third best/ Locally relevant but mediocre R&D	(4) Bad strategic option/ Locally irrelevant and mediocre in terms of quality/ Vicious cycle

Table 5.1: A taxonomy of public policies funding research

Public policy should avoid funding research that is locally irrelevant and internationally uncompetitive. However, this probably constitutes a major part of current funding. For example, after many years of effort designed to root out such problems, the 2008 UK Research Assessment Exercise shows that 36% of research activity in UK is internationally recognised but not internationally excellent, or is of national quality only. We can imagine that the situation in some countries is likely to be much worse. One impact of ERA and Fifth freedom policies will be to reduce fourth quadrant effort in favour of second quadrant. However, it is less certain what will be the effects on the first and third quadrant.

Secondly, R&D policy should prioritize locally relevant R&D by requiring that domestic users play a bigger role. However, problems related to the participation of the business sector in FP programs will be further magnified in the case of the NMS. Research capacities should be linked to firm level demand through an increased share of co-funding mechanisms involving the business enterprise sector. In this way co-funding schemes should become important for connecting pockets of scientific excellence with the business sector, compared to relatively extensive support for science parks, high-tech incubators and other similar initiatives. Building research capacities in the public sector that support technology absorption and technology development in close cooperation with commercial enterprises, should enhance knowledge diffusion and the capability formation.

Third, at national level, responsibilities for innovation policy tend to be confined to either the science or the economy ministry. The increased importance of policies closely related to innovation like education, environment and economy call for establishment of better coordination mechanisms at the top level to drive through change. A much improved coordination in the NMS is required to realize potentially positive structuring effects of ERA but also to counteract negative effects of horizontal fragmentation.

Fourth, a better coordination between Cohesion, Structural Funds and the Research Framework programmes policies is warranted. However, it is not clear whether better connection between Structural Funds and FP will lead to anything other than the introduction of new RTD capacities which are not necessarily relevant to the local economy. In other words, better coordination of RTD may not by itself really solve the issue of local relevance unless the approach to Structural Funds is re-examined. There is evidence that the incentives provided by the structural funds primarily stimulate financial absorption rather than ensuring long-term effects. The cumbersome procedures involved are often further complicated by the rules of national administrations and are not leveraging national innovation capacities. An overall re-evaluation is needed to assess the role of SF in building firm and industry specific infrastructures with strong linkages to public research systems, as a means of attracting additional or embedding existing foreign direct investment (FDI). This evaluation should be approached from the perspective of growth, rather than redistribution.

Fifth and finally, Structural Funds (SF) are widely used a substitute for national funding in RTD in NMS. There are serious limits to this substitutive role and they should be re-converted into complementary funding as this is the best way to ensure local relevance and achieve broader support. In addition, while the Framework Programme may make a major contribution to R&D quality in NMS but increased FP participation will not necessarily lead to increased funding effort at the national level. In both cases, the complementary national funding will be easier to realize if there is a conscious push to ensure local relevance and to link RTD policies with broader economic development. This may lead to smaller financial benefits for NMS but will ensure higher local relevance of funded RTD activities.

5.7 From a principle of subsidiarity to principle of shared responsibility

A new policy coordination arena is only possible when there is an institutional context for its implementation. Whether a much stronger coordination between DG Research, DG Enterprise, DG Information Society and DG Regio is a solution to this challenge is an issue for further discussion. Whether the new policy coordination arena can be developed within the EU which still operates based on the principle of subsidiarity is also an issue for further discussion. While the Expert Group can see merit in both perspectives, it sees the major challenges in terms of coordination of EU and national policies.

The Barca report (2009) is fully aware of this challenge and tries to find answers within the EU innovation policy as a multi-level governance activity. By adopting the place-based approach that goes beyond the traditional dilemma of fiscal federalism of whether to decentralise or centralise any given public function, it argues that the responsibility for policy design and implementation should be allocated among different levels of government.

'More specifically, the authority governing the exogenous intervention sets the priorities, rules and general objectives for using the funding provided, leaving it to lower levels of government to implement these principles according to the context as they see fit' (Barca, 2009, p. xi).

A key ingredient of the place-based approach is that development is *'promoted from outside the place by a system of multilevel governance where grants subject to conditionalities on both objectives and institutions are transferred from higher to lower levels of government'* (p. 5). On that basis, the report regards the issue to be how to design governance arrangements under which the two levels of government share responsibility for each public good and service. Instead of allocating to each of them a certain number of services, each of them can be allocated a certain number of tasks in the provision of services of all kinds (ibid) (p. 41).

This shift from a separation of responsibilities in terms of types of services to one in terms of tasks in their provision is justified by the concept of subsidiarity. Barca's argument is that 'in the context of place-based policies, subsidiarity needs to be interpreted with reference to responsibility not for whole sectors, but for whole tasks'.

As the Report has shown, the multilevel governance that runs place-based development policies must appropriately '*combine conditionality and subsidiarity. In particular, it must allow the level of government responsible for the exogenous action to set priorities and to shape criteria for interventions (conditionalities), while at the same time allowing and promoting the freedom of the private and public actors at lower level of government to "advance ends as they see fit" on the basis of their knowledge and preferences (subsidiarity)*'.

The concept of conditionality requires different rationales which may contradict the absolute principle of subsidiarity if applied through its traditional criteria. For example, there may be conflicts between EU and national views regarding mobility policies for research scientists and engineers. From the EU perspective, mobility of personnel should be encouraged and is an essential part of ERA while from a national perspective embedding research personnel should be seen as a priority. A subsidiarity principle does not recognise the need for vertical policy cooperation. It assumes that there is one optimal policy level while in practice there is an increasing scope and need for multi-level policy action. However, it does not follow from this that any multi-level policy cooperation is good. A case for multi-level policy action must be justified in similar manner as the case for subsidiarity based policy action is justified.

We suggest shifting the emphasis away from a principle of subsidiarity in favour of a principle of *shared responsibility*. This principle has been developed in a recent EU funded study (Radosevic et al, 2008). There, a methodology was developed, which enables an assessment of which measures firstly meet the criteria of (a) shared responsibility, i.e. by which it is beneficial for a policy instrument to be used at several policy levels; and (b) beneficial alignment between different policy levels. The first step is to check economies of scale, heterogeneity, cross-border spill-overs, and frequency of use of the instrument to evaluate whether there is a case for *shared or coordinated responsibilities* in innovation policy. The second step establishes what the potential for complementarities (*network alignment potential*) is, which depends largely on whether stakeholders have complementary objectives. The questions which need to be answered in this step is: *Who* are the stakeholders? *How* do they interact? And, *What* are their respective roles and interests?

An analysis of 10 innovation policy instruments from the perspective of their potential to promote EU-wide trans-national cooperation has shown the following:
a) There is not a general case for EU-wide trans-national (vertical) cooperation potential. This potential has to be demonstrated in each individual case and would require some prior analytical work and be applied to a very specific and elaborated policy proposal. Vertical complementarities are most often quite specific and rarely general i.e. applicable across broad policy areas.

b) Within policy areas where potential for vertical complementarities may seem quite limited there are selective EU-wide areas with great potential for alignment or promotion of ERA. For example, the recruitment of skilled personnel in enterprises has in general a moderate potential for trans-national collaboration but in some selected areas, especially in those where the EU is deficient on a large scale, this potential may be quite significant. Moderate alignment potential of programmes for risk capital could be significantly changed by EU legislation in this area. Potential for trans-European cooperation in service innovation and public procurement is possible in *sectoral* partnerships at the EU level. In the case of innovative start-ups, the potential for vertical complementarities may be improved provided that we better understand the mechanisms and processes of firms' growth especially in areas of high-tech and in segments where gazelle-type companies operate. This further reinforces our first conclusion that the assessment would have to be as specific as possible to the individual policy instrument.

c) Among policy instruments assessed by our methodology the greatest potential for vertical alignment or trans-national /regional cooperation is present in the case of risk capital promotion measures, which is followed by R&D cooperation measures. Moderate overall but very strong potential for vertical trans-European cooperation is present in specific sectors of service innovation, public procurement and IPR support. Lower and similar potential for vertical cooperation is present in the case of R&D grants, sectoral innovation programs, start-ups, regional clusters and recruitment of RSE in enterprises.

d) An assessment of the potential for vertical policy cooperation should not take interests and motivations of existing stakeholders as given. In fact, very often the potential for vertical cooperation is hindered because a key stakeholder is either 'weak' (undeveloped) or missing. From our perspective, a key policy objective would be to enhance or assist the growth of the 'weakest link' i.e. a stakeholder that is essential to the process of strategic vertical interaction but which is either not developed or not oriented towards ERA objectives. Our pilot assessments have identified several of the actors who could be considered as 'the weakest link' and accordingly policy to address these issues could be described as 'supporting or re-orienting the weakest link'. For example, vertical cooperation in support of regional clusters has limited potential largely due to weak intermediary organisation for collaborative actions of regions. R&D grants and loans have moderate potential for vertical cooperation due to the limited role of EIB and absence of national governments in funding joint programs in this area. Similarly, vertical policy cooperation in programs of R&D cooperation is limited due to the orientation of national governments exclusively towards national programs.

Appendix 5.1: Open Method of Cooperation and INNO-Nets in support of vertical European trans-national cooperation

The Open Method of Coordination (OMC) has mainly been applied as a tool for horizontal coordination of activities of member states. As pointed out by Edler and Kuhlman (2005): '*For the time being the OMC means integration of methodological approaches, discursive practices and normative orientations in policymaking administrations rather than integration of policy-making itself*' (p. 63).

The task of enhancing vertical complementarities represents a new challenge for the OMC method. ERA-Net is a good example of horizontal integration facilitated by the EU. INNO-nets also represent a new initiative to enhance horizontal collaboration in area of innovation policy with the aim to go beyond policy learning and towards joint design and implementation. However, a brief overview of INNO-Nets projects suggests that the balance is still too much skewed towards learning and diffusion of best practise and much less towards supporting joint pilot projects. In addition, there is strong need to enhance vertical cooperation in innovation policy, especially through jointly implemented projects supported by EU, country and regions.
A stronger emphasis on vertical synergies would mean that diversities should be considered not only between countries (horizontal synergies) but also between regions, countries and Community level. A vertical coordination should facilitate integration of policy making itself. In that respect, OMC seems to be only the first step in the process in order to identify areas which lend itself to EU-wide vertical cooperation.

How OMC/INNO-Nets could be used in promoting ERA, especially in promoting vertical policy cooperation i.e., cooperation between EU, national governments and regions? So far, OMC/INNO-Nets have been primarily used as an instrument for promoting cooperation between national governments. In view of this study, OMC/INNO-Nets could be used also as an instrument for promoting dialogue between stakeholders at different policy levels (national, regional and EU). INNO-Nets should be designed with a much higher share of joint pilot projects which include different organisations at different levels. However, there are two major differences when compared to established OMC which follow from our assessment of potential for trans-national cooperation or vertical integration of the 10 policy areas. First, vertically focused OMC should be confined on very specific policy areas and instruments where it is possible to identify complementarities of interests between different stakeholders. Second, the exact profile of stakeholders should be *specific to each very specific policy area*. Both of these requirements could be satisfied after an in-depth assessment of potential for vertical complementarities as outlined in this study (Radosevic et al, 2008).

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