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High Level Panel on the Socio-Economic Benefits of the European Research Area

Final Report

Research and Innovation

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High Level Panel on the Socio-Economic Benefits of the ERA

Final report

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There is no doubt that a world-leading research and innovation capacity built on a strong public science base is critical to achieving durable economic recovery. This is why the **European Research Area** is at the heart of the Europe 2020 strategy and its Innovation Union policy flagship, and the reason why the European Council has called for ERA to be completed by 2014.

Europe must increase the efficiency, effectiveness and excellence of its public research system. An open space for knowledge, this means a fully developed European Research Area, will maximise the return on research investment thus contributing substantially to growth and jobs. In an increasingly-globalised and competitive research landscape, this requires more competition and cooperation but also a free circulation of researchers and scientific knowledge - the fifth freedom. The European Research Area must cut brain drain down from weaker regions and also reduce the wide variation in research and innovation performance among different Member States and regions.

It is clear that the European Research Area will require time and substantial efforts to be fully functional. However, there are many areas where action is more urgent and where benefits for the economy and society can be optimized. Thus, the Commissioner for Research, Innovation and Science, Ms Máire Geoghegan-Quinn, requested setting up a senior group of leading economists to help identifying these areas in order to support the preparation of the Communication on the European Research Area. The *High level panel on the socio-economic impacts of the European Research Area*, chaired by Achilleas Mitsos and with Andrea Bonaccorsi and Yannis Caloghirou acting as rapporteurs, was therefore established by DG RTD in connection with the *High Level Economic Policy Expert Group on 'Innovation for Growth (i4g)'*[1].

The panel produced this report, a timely contribution to the design of the European Research Area policy. The report confirms that the European Research Area will bring benefits to the economy and to society, directly and indirectly, by generating European public goods, and by paving the way for innovation. Stronger competition leads to funding the best research, therefore boosting excellence. It also states that a unified European Research Area requires an adequate flow of competent researchers.

Many positive consequences of cross-border cooperation are shown: it allows reaching critical mass in carrying out research, a networked specialisation of research teams, better knowledge sharing and transfer, and better visibility of research results. Moreover, cooperation reduces unnecessary duplication of efforts, it provides a reliable environment to foster research by the private sector, and promotes economies of scope and administrative efficiency. An intelligent cooperation across borders complements and amplifies European resources mobilised through the Framework Programme.

The experts also highlight the importance of European Research Area in fostering research on societal challenges. It helps finding new solutions from a pan-European approach, delivering solutions tested across Member States, and opening the markets to competition. Research-based technologies and services can help European countries become leaders at world level in the creation of new markets, built around new societal needs and new business models.

Finally, the report confirms that large-scale and virtual facilities not only improve access to state-of-the-art research infrastructures by all researchers concerned, but also foster connectivity in science between all countries and regions. These facilities are essential for the EU to benefit from economies of scale, allow less performing regions to catch up in terms of excellence and, in due time, induce smart specialisation.

These conclusions give support to EU Member States, research funding and performing organisations, and the European Commission in their efforts to achieve European Research Area. I am confident that they will be an important input in the implementation of the European Research Area.

Robert-Jan Smits
Director general DG Research and Innovation

1. The mandate of the group of experts i4g includes 'to advise the Commission on research based innovation, technology creation and how it is best transformed into economic growth' and 'to assess the innovation potential and economic growth aspects of actions in the realm of the overall Innovation Union policy and assess best practices of R&I activities in that respect'.

I — Introduction and summary of main conclusions

The mandate given to the group was to identify the socioeconomic benefits expected from a fully functioning European Research Area and thus to support the proposal for the ERA framework by clearly and convincingly presenting a case for the overall socio-economic benefits of a fully functioning ERA. The issue at stake is not a dilemma between ERA and not ERA. It concerns the additional benefits from a strengthened ERA.

The major economic crisis of recent years, and in particular the crisis of public finances, has created an unprecedented pressure on research, education and innovation expenditure. This has resulted in a paradox. While growth and innovation are urgently needed, research expenditures, the most growth- and innovation-driving public spending, suffer from dramatic cuts. Justifying public spending with long-term effects becomes more difficult. Research expenditure, while being a potential saviour, becomes a victim of the need to cut public budgets. At this juncture, strengthening the European Research Area is expected to provide a significant contribution to the growth agenda of Europe by making a more efficient use of existing resources, and by the potential it has for positive spillovers from research to innovation.

The classical economic rationale for centralizing a certain policy stems from the 'fiscal federalism' fundamental trade-off between the efficiency gains that policy centralization brings through mainly the internalization of cross-border externalities, and the efficiency losses due to direct policy response to citizens' will (2). The closer the decision to the citizen, the greater is the chance that any heterogeneity of preferences will be coped with, unless there are important external consequences of such a policy. The subsidiarity test assumes by default decentralized decisions and any coordination or centralization at European level is justified only if important cross-border externalities and/or economies of scale are clearly demonstrated.

Research policy is often cited among those policies, where the subsidiarity test leads to more centralization. Preferences regarding objectives of public research are generally not very different between EU Member States, and the existence of cross-border externalities is very often the case. Cross-border knowledge diffusion leads to a suboptimal level of R & D because Member States do not take the effects of their public R & D on other Member States into account when taking decisions. In addition, research is often faced with important economies of scale, in particular when large infrastructures are required or excessive duplication of effort takes place (3).

This rationale for a higher role of EU in research policy seems to be well accepted by European public opinion. As evidenced by the annual surveys of public opinion, the 'standard Eurobarometer' (European Commission, 2012a), research consistently tops the list of policies that people believe should not be managed exclusively at national level.

But the ERA is not about centralizing national research policies at a European level. The need for a fully functioning ERA does not stem from identifying the European as the optimal level of research policy. The ERA is about organizing and governing a complex research landscape in Europe. The ERA is about the interrelated aspects of 'a European internal market for research, where researchers, technology and knowledge should freely circulate; effective European-level coordination of national and regional research activities, programmes and policies; initiatives designed for implementation and funding at European level' (European Commission, 2007a). 'The European Research Area centres around the idea of developing a more coherent overall policy

2. The term 'fiscal federalism' was first introduced by Richard Musgrave (1959) and is closely associated with Wallace Oates (1972, and e.g. 1999, 2005), followed by a vast literature.

3. See e.g. Falk et.al. (2010), Van der Horst et.al. (2010).

framework conducive for European research through mobilising critical mass, reducing costly overlaps and duplications and making more use of coordination and integration mechanisms involving all levels of policy intervention in the European Union' (European Commission, 2007b). The ERA entails the use of a variety of funding and organizational models for high performance research systems. Research fields differ enormously in terms of their requirements for cognitive, technological and institutional complementarity. In order to cope with this variety, the 'one size fits all' is not an adequate solution. There should be more room for research cooperation of variable size and heterogeneity, without fixed rules in terms of number and types of countries. In addition, the whole setting should create conditions for building complementarities across regions, countries and sectors.

The aim of this report is to explore the efficiency-related arguments in favour of a fully functioning European Research Area, while addressing any unintended consequences and, in particular any real or potential tradeoffs encountered between efficiency and equity.

Fostering European Research Area brings both direct and indirect benefits. Direct benefits refer to enhancing the efficiency of carrying out research activities, while indirect benefits refer to an increase in the potential for research to make a positive economic and societal contribution. These 'direct' and 'indirect' benefits are closely interrelated. Higher quality R & D and more R & D output raise the socioeconomic impact of R & D. The relation between research, innovation, productivity and growth is subject to strong complementarity relations.

At the heart of the analysis lies the argument that a larger pool for selection of researchers and research projects will increase the quality of research. A selection process that takes place from a larger pool is more likely to pick up the best opportunities. A larger set increases competition and this, in turn, leads to a higher overall quality of research.

Increased competition in a larger selection pool creates a pressure towards specialization. The larger is the size of the selection pool, the stronger is the pressure towards specialization. Specialization implies a finer division of labour, both internally within universities or research organizations, and through networks, joint specialisations by establishing durable and strategic relations with other actors.

The critical mass argument in favour of more ERA rests on the potential of increasing returns to scale. Scale or dimensional benefits refer to the more than proportional gain from a larger unit, due to the indivisibilities of certain capital or financial inputs, but also to the high global visibility of large-scale projects which act as magnets for attracting the best researchers from the whole world. It should be noted though that not all research is subject to such phenomena. Excellent research does not *always* depend on the scale of operation.

Coordinating research efforts at the European level will also lead to a reduction of efficiency losses caused by the duplication of efforts, or to be more precise, caused by the *excessive* duplication of efforts. A certain degree of duplication is not simply a sort of necessary evil but it is intrinsic to science, since scientific research is by definition uncertain and risky. What is the level of duplication needed (see for example the notion of positive redundancy in systems theory), and what type of duplication is needed? In frontier research we aim at the widest diversity to allow for new ideas to flourish, in applied research it might be that the coexistence of similar approaches may help to address an important challenge if those are brought together.

Strengthening the European Research Area will enhance the productivity and quality of European research, as well as the relevance of research in addressing societal challenges, and by doing so, it creates a more favourable 'leverage effect'. In other words, it increases the complementarity between public and private research investment. The relation between research, innovation, productivity and growth, although clearly nonlinear, is strong and channelled through many different ways. The private sector needs cooperation with high quality public research and also needs more accessible public research. Higher quality and more efficient European research paves the way for more research and development from the corporate sector; faster growth of young innovative companies and large productivity gains especially in the services sector, where the gap in productivity between Europe and the USA is the widest; and addressing societal challenges.

Tackling Societal Challenges is at the core of European innovation and growth strategy, and it is precisely the need to address Societal Challenges that requires a pan-European research effort. These challenges require research, development, experimentation, and social testing of new technologies and organizational models on a large, European scale. Through the ERA, Europe has the opportunity to regain world leadership in areas where innovation is hampered by the need of social adaptation. The need for new solutions requires a pan-European approach from both sides: opening markets to competition, on the supply side, and delivering solutions tested across Europe on the demand side.

The arguments outlined in this report suggest that fostering the European Research Area may lead to more and better research and this in turn may be beneficial overall because of the importance of research quality for innovation, growth and the society at large. But the benefits from the ERA may be hampered by some unintended consequences and some real or potential trade-offs.

Increased competition leads to specialization, but 'too much' specialization may be associated to increased concentration of research, and research funding, in a select few institutions (*institutional* concentration), in a few established research directions (*epistemic* concentration) or in a few regions (*spatial* concentration).

Large institutions are not necessarily more productive and more efficient, and economic analysis of science shows that there is only one level of research activity for which concentration is unambiguously beneficial – the individual scientist, or the small research team. At all other levels of organization of research there is no compelling evidence that concentration of resources is ultimately beneficial. European Research Area is not about concentrating resources in a few excellent universities or research institutes. It is about fostering excellence and mobility. In this respect, a concentration of resources is not necessarily the outcome of a dynamic process of competition and specialization.

An epistemic over-concentration, an excess concentration of research funding in established directions marginalizing emergent views, may imply a loss of diversity. Diversity is a value in science, because it preserves the pool of ideas from which discoveries may emerge. But there is no reason to believe that moving towards more research at the European level would necessarily reduce diversity. Schemes for supporting unconventional research are already being implemented by the European Research Council and there are many ways of experimenting and promoting radical new ideas.

Perhaps the most serious trade-off arises if the promotion of scientific excellence at European level results in an over-concentration of research in certain regions, widening the gap between advanced and laggard regions. The debate around this issue is considerable, with the main argument being that regions with a weaker scientific base suffer more from larger international competition, as well as from enhanced international mobility of scientists. Efficiency criteria in favour of more international competition may contradict the need for more inter-regional and inter-national equity considerations. The policy implication of this potential trade-off is that there must be clear and distinct normative criteria for different policies. Structural, cohesion policies and funds are, and should remain, spatially determined, aiming at creating the appropriate conditions for strengthening the regions' scientific potential and the conditions for their best researchers to stay home. Research policies at European level on the other hand should be totally independent of geographic criteria and must be subject only to quality criteria. Fostering quality of research should upgrade the whole research system in Europe.

The analysis focuses on research *projects*, on *researchers*, and on *research infrastructures*. For research projects, the benefits of cross-border funding but also of various forms of international joint and coordinated research priority-setting and research projects' evaluation and selection procedures are identified and analyzed.

The analysis of the potential socioeconomic benefits of the ERA through researchers' mobility is based on the universally accepted assumption on the importance of the human factor in promoting the knowledge economy and society in Europe. Mobility is not an end in itself, but strengthening the ERA requires an adequate flow of competent researchers between disciplines, sectors and countries. Mobility brings about considerable benefits to the researcher himself and benefits Europe through interaction and learning by interaction, positive externalities from knowledge spillovers and direct and indirect impacts of knowledge diffusion. But mobility, and in particular *permanent* mobility, induces 'brain drain' to where the working conditions and remunerations are most beneficial to individual researchers. Thus a key tension is created between mobility and cohesion. A number of policy measures at both European and national level should be taken, in order to promote mobility in the wider sense of brain circulation. International research collaboration can be considered as a complementary or even an alternative path to mobility. The benefits from collaboration and research joint ventures have been well established in the literature, and the EU Framework Programmes have greatly contributed in this direction.

The area where the scale factor, the dimensional effect, is the most obvious is large-scale research infrastructures. Their development entails enormous investments and costs which are difficult to be borne by individual countries. Their benefit on the advancement of science and the exploration of boundaries of knowledge may be very important. Moreover, they act as magnets for talented researchers from the whole world and provide high-quality training to young researchers and technical staff. Equally important however, where feasible, is the promotion of distributed large-scale facilities and virtual facilities (e-infrastructure), giving the opportunity to smaller and less research-intensive countries and regions to participate into the European Research Area and enabling them to profit from the wide range of competencies across Europe. The design, construction and maintenance of large-scale infrastructures can drive innovation in the business sector by creating a 'learning environment' for companies to develop new products, processes and services.

In what follows, *Section II-A* deals with the benefits stemming from strengthening of European Research Area for research *per se*, the efficiency gains leading to better quality and productivity of European research. The unintended consequences of concentration are examined in *Section II-B*, while the benefits of European Research Area for the economy and the society are reviewed in *Section II-C*. The analysis of ERA benefits at the research project level is dealt with at *Section III,* while *Section IV* treats researchers' mobility issues and *Section V* the case for more ERA in research infrastructures.

II — The case for the European Research Area

The arguments in favour of fostering the European Research Areas can be divided in two groups: direct and indirect benefits. Direct benefits refer to increase in efficiency and reduction in inefficiency in carrying out research activities. Indirect benefits refer to an increase in the potential for research to contribute to sustainable and inclusive growth. The former have an internal, research-oriented perspective, while the latter have an external, society-oriented perspective. They can be described as benefits for research, and benefits for economy and society, respectively. Overall, the benefits can be described as follows:

*** benefits for research

benefits from efficiency gains:

- larger pool of selection
- gains from specialization
- visibility and critical mass

benefits from reduction of efficiency losses:

- reduction of excess duplication

*** benefits for economy and society

direct effect on socioeconomic growth

- more R & D investment from the corporate sector
- faster growth of young innovative companies
- increase in productivity in services
- addressing Societal Challenges.

The distinction between benefits for research and for economy and society must be understood correctly. Economists have produced theoretical and empirical contributions to show that innovation and growth depend on R & D and knowledge investment. Moreover, the quality of R & D and R & D output has an impact on exogenous benefits. In other words R & D impact and spillovers depend both on the quantity and quality of R & D. This means that if the ERA increases the productivity of R & D (direct benefits), it will increase the socioeconomic impact of R & D (indirect benefits). Therefore the distinction between the two is somewhat artificial, insofar as research is not exogenous with respect to social dynamics and economic growth. However, the distinction is useful for illustrative purposes.

The integration of research policy at European level covers either the case of activities carried out directly by the EU budget or via inter-governmental arrangements and institutions, and the case of variable geometry activities. While the main arguments hold with respect to levels of integration (European and cross-border), the implementation and the policy implications differ to a certain extent. In this Report the notion of 'European' integration covers, for the sake of simplicity, either true European or cross-border integration.

Another important qualification is that vibrant research systems are based on a dynamic balance between competition and cooperation. Both elements are necessary to research quality and creativity, and neither serves the purpose in isolation. Competition fosters the efforts of researchers and ensures that public resources are allocated where the best results can be achieved, while cooperation supports knowledge exchange among scientists, team activity, creation of new scientific fields and multidisciplinary activities, use of scientific infrastructure.

As this Report will show, pushing ahead the ERA will help to achieve more competition and better cooperation.

Finally, it is important to recall that the ERA is made of several components: on the one hand there is the need for truly European framework conditions, or common standards; on the other hand, there is room for better articulation and coordination of the various policy levels: regional, national, cross-border and European.

A — Benefits for research per se

Larger pool for selection

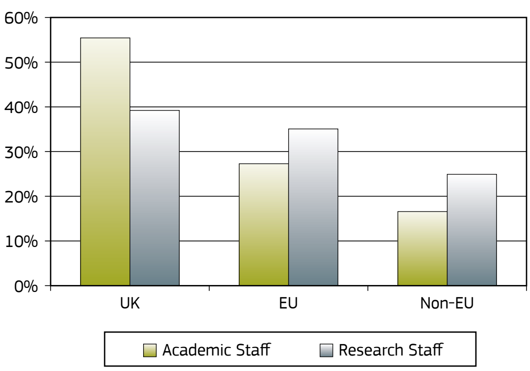
The first argument in favour of integration of scientific systems is that a selection process that takes place over a larger pool is more likely to pick up the best opportunities. In other words, a larger pool of selection increases competition and improves quality of research over time.

This principle applies differently at various levels of research systems, but always with positive effects. For example, in project selection, if scientists know that they have to compete not only with their domestic colleagues, but also with colleagues from other countries, perhaps in a Joint Programming scheme or in across border cooperation, they will put more effort in doing research. Poor research teams that would survive in a small domestic environment would disappear in a large competition in the long run. Another example is the researcher mobility: when the competition for career positions is blocked, and universities become 'closed shops', the outcome is usually less than satisfactory. On the contrary, the larger is the competition, the better is the probability that the best scientists are recruited.

This is the reason why research systems that allocate resources in proportion to the success in publishing in international refereed journals, i.e. in highly competitive outlays, witness an increase in productivity over time.

This is also why research systems in which there is significant 'in-breeding', or the tendency to recruit people from within, tend to deteriorate over time. Conversely, there is evidence that universities with a higher share of foreign researchers are among the most productive. Consider for example Imperial College (Figure 1), a leading university in science, medicine and engineering in which 60% of the research staff and 45% of the academic staff come from outside the UK, and in which the staff is recruited on the basis of scientific performance against global benchmarks.

Figure 1: **Staff composition at Imperial College London (Average 2006-2010)**



Source: O'Nions (2012)

While the causal relation between internationalization and research quality may go in both directions, the relationship is very strong.

This principle is valid first and foremost within Member States. Each of them should ask whether it is the case that too much money is allocated without competition. At the level of Member States, as it will be discussed below, there are great benefits from opening boundaries, for large but also for small countries, for advanced but also for catching up countries.

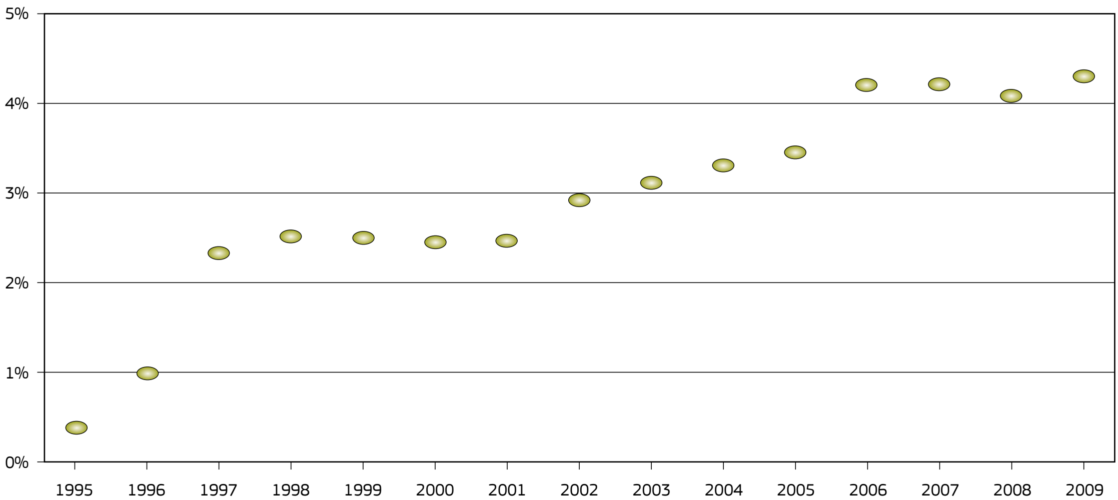
Under this respect, the increasing role of European research funding for many institutions in the last decade has already produced a number of highly positive outcomes. Also, the success of the European Research Council in fostering merit-based ex ante selection has been producing several catalytic effects. There is room for pushing ahead this positive effect, by creating a truly European system of ex ante selection of research projects, according to common evaluation standards, so that projects are directly comparable across countries.

At the ERA 2012 Conference, held in Brussels on January 30, 2012, several speakers have offered vivid evidence of the importance of competition in the European landscape for the strategies of universities, the incentives for career, but also for the creation of attractive 'role models' for junior researchers, based on merit and mobility.

Below are some figures on the growth of European funding for all universities in Sweden and for the top ones in the UK. In these cases, as in other cases discussed at the Conference, the increase of funding from Europe has led to more competition in a larger selection pool, where this is demonstrated.

Increasing the quality of European research is a major goal for the ERA. The evidence produced by the European Commission on S&T Indicators and several empirical studies show that there is still a gap to be filled in the research quality in Europe. Particularly in fast moving fields, and in the upper tail of Research quality, much is still to be done to increase the quality of European research. A larger pool of selection is a first step for increasing Research quality.

Figure 2: **Proportion of EU funding in Swedish universities 1995-2009**



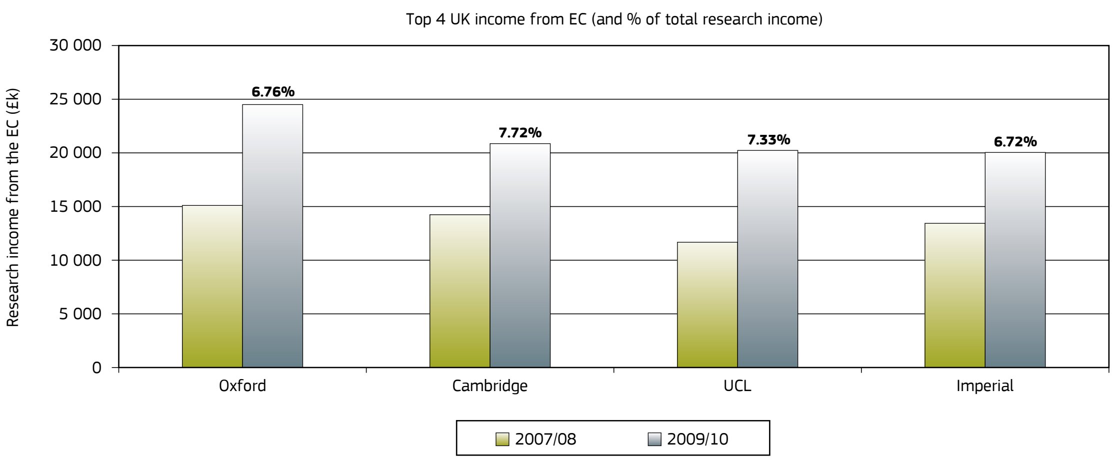
Source: Report from the Swedish Research Council, 2010. In Sjöström Douagi (2012)

One of the most robust empirical findings in the economics of science is that the distribution of scientific productivity across individual scientists is extremely skewed. This means that the most productive scientists are proportionally much more productive than those that follow in the rank. To make things simple, suppose we are able to count all the scientific work done by scientists in all their life, or all the citations they have received, or whatever indicator of quality, and we rank them from first to last. What is found empirically is that good scientists are not marginally better than others, they are largely more productive. The same evidence is available for research teams associated to most productive scientists.

One important reason for this empirical regularity is that those who obtain good results and are recognized by their community develop more new ideas.

To this epistemic factor one can add an institutional one, called the Matthew effect in the sociology of science. Funding systems that are based on

Figure 3: **Funding of research at top universities in UK**



Source: O'Nions (2012)

peer review tend to recognize scientists that have achieved good results and to fund them more generously. With more funds, good scientists train more PhD students and researchers and obtain even more results. Eventually, the initial advantage is magnified, so that those who have already received more will receive more also in the future (as the Matthew Gospel suggests).

In the jargon of economists, scientific achievements are subject to cumulative advantages (the probability to obtain good results is higher if you have already achieved others), positive feedbacks (the more you get recognized and receive resources, the more you obtain good results, but more than proportionally) and path dependency (initial conditions matter, so that for example obtaining good results, and then resources, early in a career may influence the subsequent path).

Recent works on the career path of scientists and on the academic life cycle add another important explanation. Productive scientists do not work at one problem at a time, but develop several search directions in parallel. A crucial period for scientific productivity is in the early stage. During the postdoctoral stage scientists start new research trails and diversify their search portfolio. If they are supported in getting independence, they succeed in achieving important results and subsequently attract doctoral students and post doc. Consequently they stay productive even at a later stage in their career, co-authoring with junior researchers. The turning point is therefore the period in the research career in which individual researchers become research leaders.

There are several policy implications for this regularity, as suggested in *Box I*. As far as the ERA is concerned, what is at stake is the ability of the European Research Area to support highly productive scientists and attract them from abroad.

A major turning point in this respect has been achieved with the creation of the European Research Council. One important contribution of the ERC is indeed fostering the creativity of highly productive scientists by offering them the opportunity to pursue research in an independent way as early as possible in their career.

Much is still to be done in order to foster quality not only on the upper tail, but on the whole system. A well-functioning research system, in fact, benefits from competitive conditions at all layers. It is important to work on the upper tail, but also on the average of the distribution. What is now needed is to move ahead in keeping the selection pool large, by creating a truly European ex ante selection process, extending the effects to all layers of research quality. This will benefit not only research carried out at EU level, but also at national level.

Box I: **What are the implications of skewed scientific productivity?**

What are the implications of this empirical regularity?

First, there is a justification for schemes of funding that do not spread resources equally. Most productive scientists will make better use of public resources. For each euro spent, a good scientist will produce more science, on average. There is a strong political and moral argument in favour of concentration of resources according to scientific performance. It is not the equality of scientists that matter, but the equality of taxpayers with respect to the use of their resources for the collective well-being. Spreading resources thinly without consideration for the skewness of the distribution is a false equality.

Second, good scientists are not only disproportionately more productive, they tend to be better teachers, at least in postgraduate education. In order to teach how to do research, it is important to be actively engaged at the frontier of research. There are no better people to teach about how to push the frontier of research than those who have been working at it during their entire career. They know all the false starts, the tricks, the delusions, and they have experienced the enthusiasm needed to motivate young scholar.

Third, there is an important organizational dimension in science, particularly in those fields that require advanced instrumentation. It is not only individual ingenuity that matters, but also the ability to set up laboratories, to purchase and test advanced equipment, to select and manage suppliers of laboratory materials, to hire, train and motivate large number of technical and research staff. In one word, most productive scientists have demonstrated their academic entrepreneurship, or at least their organizational skills.

Fourth, highly productive scientists tend also to enjoy social visibility, as witnessed by prizes, honorary degrees, appointments, and media coverage. From this visibility several advantages come to society: motivating young students to engage into a scientific career, persuading society to support research in some areas, or creating respect for a style of thought based on critical attitude and rigour.

International visibility and critical mass

It is sometimes argued that there is a need for rationalizing research, because of the lack of critical mass. It is not true that all research is subject to critical mass phenomena. It is possible to carry out excellent research at several scales of operation, without obvious gains beyond a given threshold. However, there are cases in which reaching a critical mass of financial resources, research personnel and infrastructure is needed.

This is particularly true for infrastructure, which is analysed in detail in a separate section of the Report. But this may be true also for research projects, and at the interface between research projects and the creation of new infrastructures.

For example, in social sciences, the need for comparability is acute. Political institutions are varied, social systems are different, even organizations are managed differently across European countries. There is great need for mutual understanding, for which social sciences are crucial. However, the quality of social sciences is diminished by the lack of comparable data. Statistical authorities make a great deal of work in this direction, but in many cases, data is primarily generated by researchers themselves, or is extremely local. Funding this kind of research nationally equates to make comparability impossible. Supporting research consortia as in Framework Programmes is a step beyond, but typically it reaches only a few countries. Networks of Excellence in the 6th and 7th Framework Programmes have contributed, as well as Eranet + initiatives. But more is needed. The quality and international visibility of social research in Europe would be greatly enhanced by new truly European programmes.

Also, Europe is the place of culture in the world. The richness of cultural heritage of European countries has no parallel in the world, in terms of languages, texts, and arts. Recent studies on innovation in urban environments show a strong relation between creativity and cultural richness. One of the missions of the ERA is to establish a better link between academic research in Humanities and the vibrant world of culture. This is achieved better by trying to reach global visibility.

With the benefit of hindsight, it can be said that the policy of using Networks of Excellence to realize integration has been a false start, not because the overall objective was wrong, but because the intermediate objective ('durable integration') was ill-defined and the instrument (a network) was weak. Integration means very different things in different scientific fields. It is not a panacea. Even in those (rare) cases in which the creation of permanently integrated structures at European level is advisable, integration in research is fundamentally different from mergers and acquisitions in the business sector. The need for better integration at European level should not be addressed mainly by forcing, with top down policies, the creation of large research actors, but by pooling resources in priority setting, selecting, funding and evaluation.

Gains from specialization

Increased competition in a larger selection pool creates a pressure towards specialization. This is a sound economic principle. In dynamic terms, the larger is the size of the selection pool, the stronger is the pressure towards specialisation.

Specialization can be achieved in two distinct ways, so that we can speak of internal or networked specialisation. The former is achieved by refocusing the activities and reallocating resources within the boundaries of organizations, the latter is achieved by establishing stable and strategic relations with other actors in order to achieve joint specialization.

Specialization of research actors is particularly important. Due to increased competition, universities and Public Research Organizations will have to decide whether to pursue excellence across all scientific areas, or rather articulate the arenas at different levels. It will not be possible to compete internationally across all areas, whereas this was clearly possible in a domestic setting. Therefore the opening of a larger competition will have the power to re-orient research actors towards more specialization.

This effect is particularly important to European universities. There is evidence that many European universities have spread their research activity thinly across all subject areas, to the point that they are poorly visible in the international arena. Another area in which universities will clearly benefit from specialization is postgraduate education, particularly for the PhD. Few institutions have emerged in Europe with strong specialization and international attractiveness in doctoral education. There is evidence that this model is no longer competitive in international competition for PhD students, particularly in highly dynamic scientific fields. The key is specialization. In a more competitive environment, each university would discover those areas that are competitive at international level and those that are not. Increasing competition will 'unbundle the university', making more visible the relative merits.

Similar arguments apply for Public Research Organisations (PROs). In some (but not all) countries PROs are required to carry out systematic reviews of their research activity, leading sometimes to decisions to discontinue institutes or laboratories that fail to meet expectations. Under increased specialization, the ability of these units to compete internationally will be a crucial element.

Following the internal specialization process, research actors may undertake reorientation of activities and resources, for example by linking internal policies of recruitment of researchers to international visibility. Following the networked specialization process, research actors enter into long term and stable agreements with partners, trying to benefit from knowledge generated in other domains. This is particularly important in multidisciplinary research.

Benefits from reduction of efficiency losses — Excess duplication

There is a further argument in favour of fostering the European Research Area at the level of projects, and this is the potential for reducing duplication.

If Member States manage their agenda in relative isolation, it is inevitable that several research teams across Europe will engage into similar projects. But in scientific competition it is only those that make discoveries first that matter and take the recognition. Discovering twice the same thing is useless. Therefore part of the investment in research is wasted. To what extent is duplication wasteful? How can it be avoided?

The argument of duplication resonates favourably in the ear of policy-makers, who are eager to demonstrate they cut spending and avoid waste of resources. This political need must be taken seriously, particularly in hard times. However, it must be admitted that a certain degree of duplication, or redundancy, or even waste of resources, is intrinsic to science. Eliminating completely duplication is harmful to science.

The reason is that scientific research is uncertain and risky. No one knows in advance whether a given project might be successful or not. This uncertainty is of course graded, from situations in which it is adequately measurable so that even private investors could risk money, to situations in which there is no measure, no insurance, and no private investment. It is exactly in these situations that the role of the public sector is crucial. Absorbing the kind of uncertainty which is not managed by the market is one of the great missions of modern States, one that only an actor with very long term view can afford.

Under uncertainty, it can be demonstrated that it is better to have more directions of investigation, rather than a single one. If one knew in advance where the expected discovery was, then it would be rational to concentrate all resources into one direction. But since this is not known, the theory of search suggests that parallel efforts should be justified.

This is even more so when the structure of the underlying problem is characterized by a proliferation of discoveries. This is what happens in most emerging sciences, such as life, information, and materials science, in which there are not big discoveries to be searched for, but rather a large number of scattered discoveries in the search space. Thus, a certain level of redundancy and duplication is warranted. Does this mean that duplication is always beneficial?

Again, economic theory offers us an important result. Under uncertainty, economic agents invest in R & D in order to get exploitable results before competitors. This is called patent race in the economic literature. It can be shown that this competition is likely to be socially wasteful, in the sense that there is excess investment into R & D. If competitors could agree upon a joint strategy, they would save money. But of course agreements between competitors are precluded by competition law, and also are made difficult by transaction costs.

This logic applies also to public investment. While a certain degree of duplication is not avoidable and is ultimately productive due to uncertainty, beyond that degree it becomes wasteful. There is an inverse U-shaped curve linking the number of parallel research projects to the social value created.

This point can also be better understood by recalling the distinction between exploration and exploitation, and between science-driven, or curiosity-driven research, and mission-oriented or agenda-driven research. The two distinctions do not overlap but are both useful to discuss this point.

In curiosity-driven research duplication is not avoidable and is ultimately socially beneficial. The dynamics of knowledge are more a product of epistemic internal tensions than of external demand. Within curiosity-driven research, the trade-off between exploration and exploitation takes place in the selection of the research agenda: exploring is more risky and potentially more rewarding, exploiting leads to normal science and consolidation of existing paradigms. The trade-off is different in agenda-driven research. Here the role of external demand is more relevant. In all cases it is important that policies concentrate on public goods, with clear added value of public intervention, in order to avoid the crowding out of private investment.

How can excess duplication be avoided? We believe that the European Research Area offers a natural environment for this goal.

First, it is important that national governments and their agencies share a common view of a number of key scientific and technological areas. This has been done effectively in the past few years through the Technological Platforms, the ERA-Net programmes and several exercises of technology foresight. These exercises are important not because they allow to anticipate the future (which is a notoriously difficult business), but because they increase the strategic flexibility of actors faced with an uncertain future. By sharing a common view, national authorities are in a better position to define their own priorities and allocate money to joint programs more confidently.

Second, Joint Programming initiatives may help to structure entire research areas in a coordinated, yet flexible way. They allow for some duplication, but reduce it to the appropriate level.

Third, EU funded research may take up more ambitious goals of achievement of results, channelling research efforts towards commonly agreed directions.

The financial crisis and the research paradox

The financial crisis started in 2008 has resulted in a deep recession, the rise of public deficits, and a large and growing stock of public and private debt. There are serious concerns about the ability of advanced economies to recover from the crisis in the short term.

The public budget crisis has created an unprecedented pressure on research and innovation expenditure. In their effort to cut the public budget, in many countries, governments have cut the appropriation for higher education and research. In the private sector there have not been dramatic cuts, after the emergency in 2008-2009, but the rate of growth of expenditure has levelled down. Overall, expenditure in R & D suffered.

This has created a paradox. Research is at the same time the victim and the saviour. Governments at the same time claim they need growth and innovation, and cut the public expenditure that might lead to growth and innovation. In doing so, they compromise their ability to build up a robust growth in the next few years. Even worse, there is the danger that the attitude to reduce the R & D expenditure is kept for several years in the near future.

This situation is particularly damaging for Europe. While Europe is trying to face the challenge of the strongest scientific and technological system in the world, the United States, it is clear that a new challenge is already in place from Asian countries. These countries have a positive demographic balance and do not suffer dramatically from public debt constraints. They can invest public resources for several years in line in the near future. They have chosen a long term catching up strategy which is not based on the classical industrialization recipe (build up a manufacturing infrastructure with intensive capital investment, but based on foreign technology), but are trying to build up their own technological leadership in selected fields. Being late comers, they try to establish leadership in new and emergent scientific and technological areas. The recent and sudden reorientation of countries such as China and Korea towards sustainability is an impressive demonstration. Moreover, they have learnt rapidly that quantity is not quality, so that, in parallel to investment into capacity building, they have now in place sophisticated policies to push their scientific base towards ambitious goals of quality (e.g. in terms of share of publications in top journals).

These factors place a difficult challenge to Europe. In the next few years, what has so far been an exception will become daily reality: European scientists will be invited to take positions in Asian universities and research centres.

The historical experience has shown that it is during the deepest crises that the seeds for future innovations are thrown. In order to address the research paradox there are several interesting proposals, for example for introducing a different treatment of higher education and research expenditure in order to determine the 3% budget deficit constraint.

Whatever the decisions at the level of Member States and European Union, it is important to underline that the ERA is by itself a contribution to the new growth agenda for Europe after the crisis: on one hand it will make better use of existing resources, on the other hand, it has the potential to increase the positive spillovers from research to innovation.

B — Addressing unintended consequences

The arguments outlined above seem quite strong. They suggest that the ERA may be beneficial to research. They are also backed by sound economic reasoning and robust empirical evidence.

Increased competition leads to specialization. There might be the concern, however, that 'too much' specialization is achieved, leading to unwanted outcomes. One fear is that specialization may be associated to increasing concentration of research funding in a few excellent institutions (universities, research organizations). Related concerns, discussed in separate sections of this Report, refer to concentration in a few regions or territories and to concentration in a few established research directions. Let us label these three forms of concentration: institutional, spatial, and epistemic, respectively.

The starting point of the discussion is that the issue of concentration is very serious and should be addressed carefully. The reason is that scientific systems are indeed subject to dynamic conditions of increasing returns, or positive feedback. Initial advantages tend to cumulate over time and create conditions of irreversibility. It is therefore important to understand very clearly the reasons underlying concentration and to design policies in order to counterbalance potentially negative outcomes.

Does the ERA lead to concentration of resources in a few large institutions?

Concentration of resources on highly productive scientists is beneficial and should not create concern. Highly productive scientists are the backbone of scientific systems. There is a deep rationale for science policies that support the emergence, consolidation and leadership of highly productive scientists. If the ERA would contribute to scientific leadership, it would do a good job.

With respect to institutional concentration, the concern goes this way: increasing competition in the access to research funding may lead to a situation in which excellent institutions receive a disproportionately large share of resources, leaving almost nothing to less-than-excellent institutions. In this scenario a few powerful universities or PROs dominate the research landscape, while all other institutions receive less than proportional resources, sometimes leading to exit from research competition. This is a potential result, for example, of a highly progressive formula for funding research, based on research quality scoring. Is this outcome a necessary consequence of increasing integration at a European level?

This is not the case. The economic analysis of science shows there is only one level of research activity for which concentration is unambiguously beneficial- the individual scientist, or the small research team. At all other levels of organization of research (i.e. department, university or research organization, region or country) there is no compelling evidence that concentration of resources is ultimately beneficial. Concentration is associated to an increase in size. Large institutions are not necessarily more productive and more efficient (see *Box III*).

To be more precise, there is one strong argument for concentrating resources into large organizations, i.e. competition for status, also called positional competition. It must be recognized that highly productive scientists tend to agglomerate with colleagues of similar status. This would be done better by being hired by the same universities or PROs. In turn, the latter would benefit from reputational gains, which are conducive to better funding.

However, it must be reminded that reputation building is a long process and is not irreversible. In research, no position should be considered as being held forever. It must be preserved a system where scientific challenges may come from whoever researcher, irrespective of the reputation of his employer. It is important to leave competition open, without transforming the intrinsic asymmetric distribution of scientific productivity and recognition into locked systems of positional or status rents.

This means that large and prestigious institutions must only be the outcome of a bottom up reputational game, driven by consistent internal policies for recruitment of top quality researchers over time, across all departments, and not the outcome of historical inertia or top down political decision.

If this is the case, there is no concern. Public policies should foster excellence and mobility, as we will illustrate below, and let the system adjust.

While economies of scale are rarely a decisive factor in research, economies of scope play a greater role. New knowledge often proceeds from the creative combination of ideas from disparate sources. Particularly in fast moving fields (information, materials, cognitive and life sciences, and their intersections), new advancements required extended interaction among members of different scientific disciplines and laboratory practices. At the same time, despite recent changes, science is still largely organized around disciplinary communities that produce scientific results in discipline-based laboratories and publish in discipline-based journals. This means that economies of scope or cooperation among disciplines take place after a certain degree of division of labour in scientific practice is achieved. In other words, good cross-disciplinary science is born out of scientists that have a strong disciplinary training, have achieved success in their background, and generate new ideas through the negotiation of their perspectives.

Box II: **Stylized evidence on economies of scale in higher education and research**

The existence and magnitude of economies of scale in higher education and research is a controversial, empirical issue.

In higher education the origins of economies of scale are identified in educational technology: teaching to 20 or 100 students consumes the same amount of teacher's time, while the quality of student-teacher relation diminishes, but only after a certain point. Furthermore, there is some indivisibility in the use of infrastructure. The literature confirms that economies of scale do play a role in higher education.

With respect to research, on the contrary, the prevailing literature is negative. There are increasing returns at the level of research teams, particularly in laboratory science, but these are exhausted at a relatively small team size, less than ten researchers.

No economies of scale have been consistently found at higher organizational levels (i.e. department, or university). At these levels there are diseconomies of scale associated to bureaucracy and administrative burden, which are detrimental to research flexibility and speed. There is no compelling evidence that large universities are more efficient.

Therefore in principle small to medium-sized specialized universities, formed by a small number of research teams whose size is beyond the critical threshold might be as efficient as large universities.

Clearly, if universities follow an institutional model in which faculty is thinly spread across many research fields, and then the threshold for efficient research is more likely not to be reached. Only in this case there is room for enhancing research productivity by coordinating or merging small universities. But the focus should be on research teams, not on departments or universities. Organization of research at the microstructure, i.e. research team, is the single most important factor.

One might argue that this is done better in large institutions, such as large universities or PROs. But again, the critical variable for economies of scope is not the size of institutions, but of research teams.

Does the ERA affect economies of scope at the appropriate level – that is, research teams? The answer is warmly positive. Being subject to more intense competition for funding, researchers will find it rewarding to look for economies of scope not within their mother institution, which in most cases may not have the critical size across all research fields, but across institutions. By making easier, smoother and more rewarding the mobility and cooperation across Europe, research teams may discover complementary competences. We might speak of network economies of scope, as opposed to internal ones.

The ERA is a great opportunity for highly productive research teams, whatever their country or institution of origin, to achieve economies of scale and scope.

Consequently, although some concentration of resources is a necessary (and positive) consequence of increased competition, this should be primarily at the level of individual scientists, research teams, or departments but only moderately at the level of institutions, i.e. universities.

As the OECD has argued: 'When taking into account the diverse objectives of higher education, the model of concentrating resources in a few institutions is not necessarily superior to the model of supporting excellent research departments across the different institutions and regions in a given country' (OECD, 2009, 14). As we have seen before, European universities are heterogeneous collections of departments of highly variable quality. Forcing less-than-excellent institutions to abandon research altogether may be damaging in the long run, because a well-developed research and higher education system must have all layers in good shape. Also, in some sense, there is a limit to excellence, insofar as there are probably diminishing returns to excellence, when it is concentrated on an extremely small number of institutions, simply for historical reasons.

In addition, concentration of resources in a few excellent universities may be beneficial only insofar as the overall academic job market is thick, mobile, and fully competitive. If the academic staff at all levels are free to move without constraints, then highly productive scientists will find it convenient to agglomerate in a few universities. However, if there are limits to mobility due to external constraints (accommodation, status, or family ties), or if there are not wage disparities that may compensate for the cost of mobility, then concentrating resources in a few institutions result in damaging highly productive scientists working in less excellent universities.

Thus, one thing is to argue for concentration of resources as positive outcome of a dynamic process of competition and specialization, another is to conclude that resources should be concentrated in a few excellent universities. The latter is neither a necessary nor a desirable outcome. The simple principle is that resources should follow quality, wherever it is found.

Does the ERA lead to more inequality in the spatial distribution of research?

The other important debate surrounding the ERA refers to the relation between excellence and cohesion, or between selection criteria dependent on peer-refereed quality, by definition neutral with respect to geographic factors, and selection criteria that are responsive to place-based policies. What is at stake, here, is the possibility of spatial concentration of research activities in more advanced regions and countries as an effect of European integration. If left to itself, the internal dynamics of scientific quality tends to accentuate the differences, and to exacerbate the spatial concentration of research activities, leaving laggard regions and countries in Europe with a perspective of depauperation. Asymmetric distributions are also found at geographic level. Let us use the expression 'place' to cover whatever geographic dimension is relevant to the discussion (country, region, and local territory).

This argument needs to be addressed openly. It has been raised repeatedly in the past. In a larger competition places with a weaker scientific base may suffer more not necessarily because governments are not oriented towards quality, but because there is insufficient investment and the overall context is characterized by backwardness. The benefits from specialization accrue to a place if there are some baseline conditions and there is sufficient internal mobility. If a place has a poor research base, it is possible that dynamic gains from international integration are never reaped. For example, it takes time to lead research team to excel in the international competition. If resources are reduced, it may be that negative feedback take place, leading to deterioration. Or it may happen that talented resources are subject to brain drain.

It might be impossible for a less advanced country to offer talented young scientists or engineers the same income than they would receive abroad, or in large multinational companies located in the country. This effect is serious. This argument is similar to the so called 'infant industry' argument in the theory of international trade. According to this argument, an industry which is in its infant stage is vulnerable to international trade, because it has not yet developed the conditions for economies of scale. If placed in the free trade condition it may disappear due to cost competition from more mature industries. Therefore, the argument goes, it is reasonable to protect infant industries against international competition, at least until the point where economies of scale are developed.

There has been considerable research and debate around this principle. The prevailing view is that it has limited temporal validity, insofar as it does not predict how long the protection should be warranted. Protecting domestic industries for long periods favours inefficiency and rent seeking. In addition, protected industries may never have the incentive to develop economies of scale. The experience of Asian economies has shown that the early involvement into international trade is beneficial.

Do they imply that the criteria for selection based on excellence, or quality, should be tempered by cohesion considerations? We do not believe this is the case, or that this would benefit laggard countries and regions.

Interestingly, most recent evidence on the impact of EU Framework Programmes on the involvement of laggard regions is highly encouraging. They show that the involvement of research teams into international research consortia has the effect of stimulating productivity and collaborative behaviour. Furthermore, being involved into FP projects with teams from scientifically richer countries significantly improves the probability of getting funded in the future. This means that, contrary to widely diffused concerns, excellence in research and cohesion are mutually compatible.

What does this argument tell about research systems? We believe the policy implication is that there must be a clear division of labour between policies that are subject to different normative criteria. Research policies must only be subject to quality criteria of international nature, because any compromise on quality results in adverse effects. There is no reason whatsoever for arguing that a scientist living in a poor region should be allowed to perform science according to more relaxed quality criteria. Research policies at European level should be independent of geographic criteria. Structural Funds, on the contrary, should be used for place-based research policies aimed at building up the scientific base, creating the human capital, and protecting the domestic base until it is able to compete internationally. While the allocation of funding for research at European level must follow quality criteria without consideration for geographic factors, Structural Funds are by definition tied to a territory. If there is concern that policies for research aimed at quality might encourage domestic researchers to go abroad, governments may use Structural Funds to build up the structural and organizational conditions for their best researchers to stay home.

Luckily enough, the cycle time needed to compete internationally is not too long. For the same reasons why science is subject to positive feedback and cumulative effects, it is possible that a few highly creative scientists establish extremely productive laboratories and schools also in relatively disadvantaged countries and regions. The international experience shows that it is possible to reorient towards international standards in slightly more than a couple of full doctoral cycles, say between 5 and 10 years.

Box III: **The role of research excellence for catching up countries**

At the ERA 2012 Conference, held in Brussels on January 30, 2012, there have been several speeches coming from catching up countries that have joined the European Union recently, or entered the accession process. They claim that the effort (sometimes very hard, given the low level of public funding for R & D due to budget difficulties) to align the national system to European research criteria is extremely powerful. In the medium-to-long run it induces higher effort and better quality in the research system. For example in Latvia the success rate of projects in FP7 is at 22,1%, not very far from the best European countries. There are also systemic spillovers from adopting research excellence criteria. The convergence towards the ERA is an explicit goal of national policies, which has led to an ambitious plan to increase substantially the effort dedicated to R & D in the near future (Figure 4). The increase in the R & D ratio will come from net increase in expenditure.

As another example, the Croatian government decided to open the national academic system by fostering the recruitment of foreign researchers and pushing domestic researchers to compete for EU funding. In a few years both the number of foreign researchers entering the country or the amount of EU funding received increased tenfold. It is estimated that over a decade the average productivity of researchers increased three times (Duĭc, 2012).

With respect to the Portuguese experience, Horta (2010) states that the effort to include the research system into a larger competition at European level has greatly strengthened its international orientation. While it has not produced the emergence of one or a few globally competitive universities, yet it has improved both the top performance and the average. Summing up: 'Portuguese national universities have an international scope that they were unable to have before 1986 (i.e. year of accession into EU) and their integration into global knowledge networks can bring potentially important benefits for the country' (p. 76).

At the same time it is fair to admit that the role of research for growth has been somewhat overstated in laggard regions and countries. The argument has been often made that more research equals more growth, using a highly simplified version of endogenous growth arguments. Quite differently, the robust relation between R & D investment, productivity and growth holds for long periods and for many countries, not necessarily in the short term and for countries with conditions of backwardness. Furthermore, it is not only important the production of knowledge, but also the circulation, diffusion and utilization of knowledge.

The negative externalities are somewhat more severe for industrial development, for which a whole host of external conditions must be met, than for research activity.

Rather, a clear strategy for growth must make a distinction between those scientific areas in which the realistic goals is to compete internationally, and those areas where this is not achievable at least in the short-to-medium term. In all areas the mechanisms that help to maximize the spill- over of research into innovation, productivity and growth should be put in place. Finally, there is no reason to believe that the best way of catching up depends on research. It may depend, on the contrary, on imitation, on the adoption of innovations developed elsewhere, on non-technological innovation, or the like. Overselling research only leads to loss of confidence.

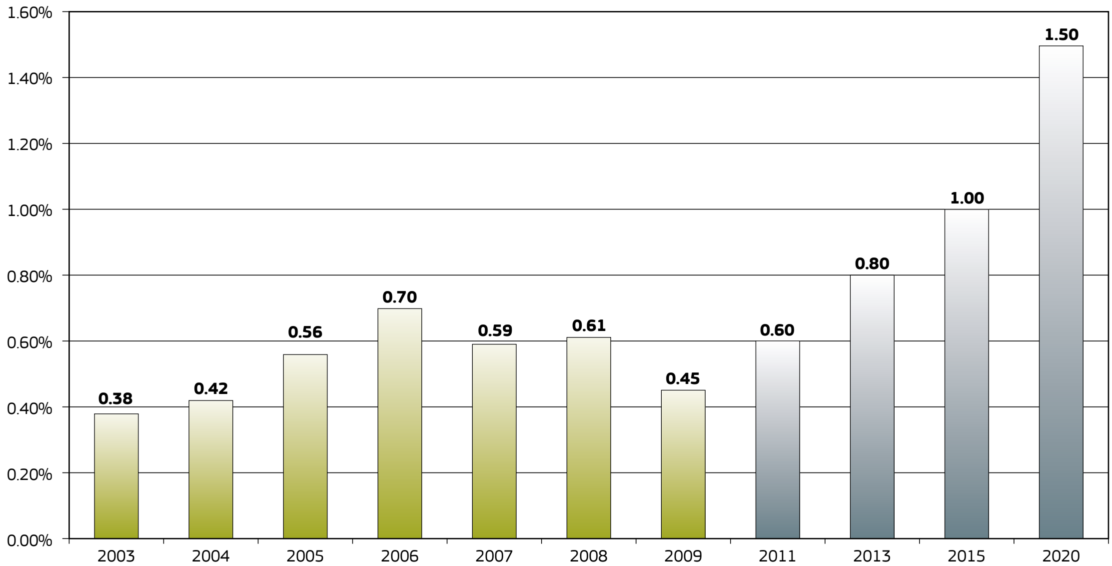
Thus, the cohesion debate should not be addressed by relaxing the excellence criteria, but rather by sharing a common view on how to create the conditions for catching up.

Does the ERA lead to less diversity in science?

It is argued that the integration of research systems may imply a loss of diversity. This may be due to excess concentration of research funding in established directions, marginalizing non-mainstream research traditions, challenging perspectives, or emergent views. This can be labelled epistemic concentration, or loss of epistemic diversity. By epistemic diversity is meant the ability of a research field to explore in parallel many directions in the search space, rather than converging around a few directions. Diversity is a value in science, because it preserves the pool of ideas and experiments from which discoveries may emerge, often against all expectations. However, since in the scientific activity there are increasing returns from adoption, epistemic diversity is at risk. If left to itself, scientific research may develop a tendency to work only on normal science, or puzzle solving within an established paradigm, rather than working on anomalies and possibly on radically new discoveries.

Models of topic selection by scientists suggest that there is a choice of the direction of research in which it is most likely to find publishable results. Here scientists

Figure 4: R & D intensity in Latvia, 2003-2020



Source: Volkova (2012)

face a trade-off: if they choose topics which are completely new, they have some probability to arrive first and to get recognition, but there will be few colleagues active in the field who will quote them; if on the contrary they focus on crowded topics, in which there are large active communities, they have less probability to find important results, but they will be cited more largely. The choice depends, among other things, on the risk propensity of scientists. Now, the propensity to take risks is a function of the design of the institutional system. If scientists are rewarded by fast and large recognition, they may decide to focus on topics that are already studied by many others.

Reduction in diversity is a serious risk for scientific systems. Even more perversely, the dangerous effects are felt only after a certain time. Scientists working in the mainstream receive recognition, and they may not perceive the need for unorthodox perspectives. This is why the preservation and enrichment of diversity is a systemic property of scientific systems, not something that may be required from individual scientists. Good scientific systems support excellence at the core, but also maintain flexibility for radically new perspectives in the fringe. No one knows in advance whether they will prove successful, but nevertheless they should be preserved from conformity pressures. This is clearly a difficult challenge for scientific systems, because it is not always easy to distinguish between radically new, but serious, science, and unsupported claims.

Due to these factors it is reasonable to ask whether diversity is fostered or reduced by a process of progressive integration at the European level. The answer is not obvious.

Because of increased international competition, and the weight of top journals, there is some risk that scientists that want to get funding stay conservative, or publish in the mainstream. Usually this behaviour grants more citations. An unorthodox scientist, the argument goes, may survive better in a national environment with less competition. This is probably true.

But there is no reason to believe that it is not possible to enforce diversity-enhancing mechanisms at the European level. ERC is already implementing schemes for supporting unconventional research. Are Member States prepared to invest in this direction? For example, it might not be needed for young scholars with radically new ideas to have an established publication backlog: perhaps their ideas are so new that they take more time to find their way in the literature. Perhaps they have been rejected by top journals because they are too radical. Then why not experiment forms of ex ante selection that leverage not on the publication records, but on the subjective, anticipatory evaluation of top scientists and technologists? Why don't we think of a funding mechanism that allocates a given share of funding to deliberately unconventional research?

We believe this is an open game. Diversity might be reduced by the European integration, if this is applied conservatively. But this is not the only possible outcome.

The sovereignty argument

One important debate underlying the growth of the ERA refers to the degree to which the integration of research policies at European scale places into question the sovereignty of Member States. The answer is definitely no.

There is a simple reason why this is the case: the public research system is, by and large, still funded through taxation. There are sound economic principles behind the fact that modern States fund research systems on their general budget.

Since there is no taxation without representation, it must be recognized that research policies have to be accountable to taxpayers to a great extent. Therefore the role of Member States is unquestionable. The perspective of the ERA is not a single, centralized research area. At the end of the process, there is neither integrationism, nor the elimination of the role of national ministries, research councils and funding agencies.

The notion that a larger selection pool is to be preferred is not accepted by all. An influential counter-argument might be labelled as follows: 'it is better to be the King of your garden than the gardener of your King'. In other words, if scientific systems remain national, it is possible for many scientists to get recognition and social prestige, while in an enlarged competition this would be more difficult. In turn, it may well be that society benefits from people that have only national scientific visibility, perhaps focus on research issues of local interest, but who are not necessarily engaged into international competition.

This argument may have merits at the individual level. However, it is remarkable that no entire scientific community is prepared to support this view. It is also difficult to find authoritative scholars who advocate the 'King of the garden argument'. Thus this counter-argument seems therefore to be plausible at the individual level, perhaps for part of the scientific communities, but not compelling for governments.

A larger research area will generate not only sector-based and inter-sector-based spill-overs, which are traditionally of interest to individual national governments, but also international spillovers, which are of interest to all Member States. It will support the creation of European public goods, or public goods that will generate positive externalities for all Member States and all actors.

In order to generate such goods, Member States, in the interest of both research actors and taxpayers, should recognize a greater role to inter-governmental cooperation, to the European Commission, and to cross-border cooperation. The discussion carried out in this Report has shown that the coordination of research policies at both cross-border and the European level is a largely positive sum game, not a zero sum game. There are large benefits from a voluntary, long term, variable geometry process of coordination.

However, we should not forget the possibility that transaction costs are so high that the benefits from positive sum games are dissipated. Thus the ERA should systematically be subject to a principle of lean organization, so that not only the administrative burden is minimized, but also the political processes are made transparent and simple.

On the administrative side, it is important to accelerate the process of simplification of procedures, based on the principle of trust. How would this be implemented? The time-to-contract should be improved and stabilized across programmes.

On the political side, there is much work to be done in the coordination of national policies and the creation of truly European public goods. There is an important dimension under which the ERA can contribute to the construction of a new Europe. During these years of financial crisis, it has often been remarked that there is a need for new European governance, based on better involvement of citizens in decisions. The research system is one in which, by long historical tradition, decisions are inextricably the outcome of a mix between bottom up and top down processes. Researchers know how to interact productively with governments and European institutions. Perhaps the creation of the ERA might become a role model for Europe at large.

C — Benefits of the ERA for economy and society

Does the ERA benefit only public research, or are there positive implications for the private sector and for society at large?

Indirect benefits are those that accrue to European economy and society via the activation of mechanisms that maximize the spill-overs from research. We know from research and from experience that the relation between research, innovation, productivity and growth is highly nonlinear and is subject to strong complementarity relations. This means that it is not enough to advocate the ERA as enhancing the productivity and quality of European research. What is needed is to clarify the specific mechanism through which the benefits can be reaped in a systematic and permanent way. What is the ERA component that will pave the way for innovation?

This Report sees large benefits coming from:

- more R & D investment from the corporate sector;
- faster growth of young innovative companies;
- increasing in productivity in services;
- addressing Societal Challenges.

Complementarity between publicly funded research and private R & D investment

Can the ERA contribute to increase the complementarity between public expenditure in R & D and private investment? How can we obtain a more favourable leverage effect?

There are at least three large expected benefits stemming from the ERA:

i) larger accessibility of public research;
ii) better risk sharing between public and private undertakers;
iii) early involvement of industry in market shaping.

Larger accessibility of public research

It is well known that industrial research laboratories greatly benefit from access to public research, particularly in fast growing fields. The access to European research is currently hampered by fragmentation: companies (perhaps with the exception of large ones) can hardly identify sources of knowledge outside their country. There is a need to improve on readability, accessibility, and responsiveness. More coordination of research agendas of Member States at European and cross-border level brings more transparency and accessibility of public research. The linkage between research and innovation established in Europe 2020 fosters mutually beneficial cooperation.

Furthermore, a larger and more European selection pool of human resources would clearly benefit companies. Building a pan-European job market for researchers would not only favour the recruitment of best talents in public research, but also in corporate R & D. It is important that the notion of mobility assumed in policy-making in the ERA includes mobility between academia and industry and vice versa.

In recent years, there have been concerns about the tendency of European firms to re-locate R & D activities abroad, particularly in the USA and in Asian countries, and the relatively small amount of foreign direct investment inflows for R & D. One problem, often argued in stakeholders' debate, is the relatively low level of mobility and openness to international careers found among European graduates and researchers. By fostering mobility across European countries, the ERA will contribute to a larger job market for both public and private research.

Better risk sharing between public and private

The complementarity between the investment of the public sector and private R & D is enhanced if the overall risk is shared according to clear principles. In fact, it is well known that the public subsidy to private investment in R & D is economically justified due to the fact that private investment has a social rate of return which is systematically greater than the private rate, generating insufficient incentive to invest. However, it is subject to potential problems of misallocation of resources and deadweight losses. One of the policies for reducing these risks is to increase the profile of risk of R & D funded with public resources. If public subsidies are used to fund research which is too close to the existing market, public resources will substitute for private ones, without additionality effects. The key is to support applied and targeted research, with a clear industrial focus, which however exceeds the rate of risk normally assumed by private companies.

In all these cases the best that the public sector can do is to fund risky R & D while at the same time reducing the negative externalities and preparing the creation of large markets. Here there is an important role for the ERA. If this is the case, complementary resources from the private sector will accrue, because companies will anticipate a better rate of return adjusted for risk. It is not enough to support private R & D with public resources. As the Expert Group on The future of EU research policy has remarked, to increase the private investment into R & D, which is still at unsatisfactory levels what is needed is to raise the expected return, which in turn depends very much on the size of the final market and the time to market.

With the Europe 2020 view, the European Union has taken the right direction, by embracing all framework conditions that may favour the undertaking of innovation. This approach is also prominent in the recent review of the Single Market and in the subsequent debate at the European Parliament.

The integrated approach advocated by Europe 2020, keeping together research, innovation and public demand has the potential to raise the expected return from R & D in a permanent way in Europe.

The ability of public research to leverage more private R & D investment, however, depends on the stability of a truly European integration process. European funding for research is planned for time horizons that go beyond national legislatures, which is an extremely powerful tool for stabilizing the expectations of research actors. If funding at the European level could be associated to more coordination among Member States on shared research agendas, using cross-border funding schemes and variable geometry configurations, this would create a reliable environment for complementary decisions by private actors in the long term.

Furthermore, the creation of mechanisms linking research to innovation to public demand, as advocated by the Expert group on 'The future of EU research policy', could greatly increase the leverage effect on private investment.

Early involvement of industry in market shaping

Some of the best success stories of European industrial research are represented by those cases in which companies have been able to lead the technology race and to establish standards. The introduction of fly-by-wire in the commercial aircraft industry, the creation of GSM in mobile telecommunications, the growth of capabilities in satellite development and launch, the invention of compact disc, and more recently the emergence of the wind energy industry are all cases in which European companies participated very early in technology development and were able to anticipate competitors in setting the rules of competition. This is not to say that it is enough: as the case of mobile communications shows, competition is fierce and no established position is safe. Also, there is possibility that other regions of the world benefit from investment in public research carried out in Europe, for example by acquiring promising a technology through mergers and acquisitions.

It is now recognized that the creation of industrial standards is a complex market-shaping process, which takes place much earlier than in formal procedures of standard setting bodies. Most often, standardization starts as early as in the research stage. For the European industry being involved at an early stage in research for new technologies is a key advantage in international competition. Most studies show that location decisions of firms are influenced by proximity to markets and the availability of highly qualified human capital. However, a recent survey on the top 1000 European companies in terms of R & D investment, in which the sample (13% response rate) represents 30% of total R & D investment by the business sector has added an interesting dimension. When asked which the most important policy measures are for increasing private R & D, respondents list: (a) publicly supported loan and guarantee schemes; (b) meeting product market regulation and other legal framework conditions (Cincera, Cozza and Tubke, 2010).

This is particularly important for technologies oriented towards the resolution of Societal Challenges. In all these cases there will be a complex process of market creation and market shaping, linking deep social needs to functional requirements, to technical specifications, to industry standards. In all Societal Challenges there is a blend between technological and non-technological, or social, innovation. There is no way to develop and introduce new technologies without a prolonged and deep involvement into the user experience. This kind of innovation is user-intensive and context-dependent. There is great benefit in involving industry very early in the development process, that is, at the research and user experience stages.

Now, the crucial point here is that European research will lead to the creation of new markets, based on new societal needs and new business models, for which standards are not established yet. Think of smart use of energy, environmental risk mitigation, solutions for urban congestion and mobility based on IT, or new solutions for healthcare delivery. There is a huge opportunity to create a full cycle of exploration and exploitation, linking leading edge research, user involvement, business model testing, and commercial valorisation.

Fast growth of young innovative companies

Recent evidence on European industrial demography suggests that there is a missing actor in the innovation landscape - young innovative companies that grow large and fast, generating income and value added employment. This is not to say that start-ups are not created- they are probably too many, but very few of them are able to grow in size. Consequently, the industrial dynamics suffer from a lack of turnover at the fringe of the size distribution, a structural factor that is associated to innovation. It is well known that a subset of young innovative companies is represented by those that are born out of research results. The difficulty of these companies in growing large is also a major dissipation of resources, because the potentially large spill-overs of research are greatly limited.

The reasons behind poor dynamism of young innovative companies are complex, and many of them have nothing to do with research. However, one important reason is that young innovative companies that are born out of European research fail to consider the need to address global markets early in their life cycle. This attitude should be created not at a later stage, but starting from the environments of research, at least for those that have a personal and institutional motivation to engage into commercialization of research.

Now, there is a difference between considering only national markets and starting with a deliberate large market orientation. Most start-up companies born from research in Europe only target their domestic market, due to perceived obstacles in language, regulation, distributive structure, and administrative burdens. While most of these obstacles are the object of framework policies, and not of research policies, it is important that these considerations are fully incorporated in the design of research policies.

The creation of a large, pan European market for early stage finance is a major step for providing these companies with a favourable environment. At the same time, investors in early stage finance, either from the public or the private sector, find that the rate of return of investment is much larger if entrepreneurs have an orientation towards entrepreneurial success and growth, rather than an orientation 'to pursue research with other means'. This attitude will greatly benefit from integration of research policies at the European level.

Here there is a major merging point between the ERA and Innovation Union. The research community should support any effort to make the financial environment more friendly to risky innovation, because this ultimately benefits research itself, and society at large.

Impact on productivity in services

The European Research Area can contribute to economic growth via a stronger influence of R & D on productivity. To see why this is the case, we need to set up an articulated argument. According to the KLEMS studies, the main reason behind the gap in productivity between Europe and USA in the last decade is to be found in services, not in the manufacturing sector. In turn, this gap in productivity is responsible for the largest share of gap in the rate of growth of GDP.

Following the diagnosis on the gap in productivity strong policy implications have been formulated. In order to enhance productivity in services structural reforms are usually recommended. They have two main goals: removing barriers in the markets for services, and allowing more flexibility in labour markets. Both factors contribute to growth in productivity in services, both from the demand side (increasing competition) and from the supply side (making workforce more flexible to variability in demand and customer needs).

Now, to see how the ERA could contribute to this macroeconomic issue, it is important to start considering that services are more remote from R & D than the manufacturing sector. Innovation and growth in productivity in services do not come from R & D but mainly from adoption and adaptation of IT. It is difficult to increase productivity at the front office, because it typically requires intensive labour activity, customization, and personal relations with customers. Therefore the main way in which productivity can be increased is to sustain a large investment into IT platforms in the back-office that automatize and industrialize operations that remain hidden to customers. But this investment is not, like automation in the manufacturing sector, relatively standardized. The development of software for back-office operations requires an enormous amount of detailed knowledge, as well as continuous adaptation to the needs of the front office staff. In one word, a large amount of learning-by-doing and learning-by-interacting is required. Thus productivity in services depends on large investment into IT rather than on R & D, but, in turn, effective IT for services requires large R & D investment of IT producers plus close interaction with users.

Given this background, it may seem unlikely that R & D might have an impact on productivity in services. On the contrary, it can be argued that in the long term the lack of productivity growth in services is also due to the poor quality of European research in IT. In fact, there is evidence that US companies in both hardware and software started to interact actively with large service companies back in the 1960s. In sectors such as flight reservation systems, financial services, insurance, wholesale trade, retailing, logistics, warehousing, parcel delivery, real estate, facility management, and many others, innovation in services was fostered by interaction between highly competitive service companies and innovative IT producers. In the same period, European companies tried to protect their internal market. When developing the policy of national champions, European governments actively tried to offer captive markets to domestic players.

Furthermore, many service sectors were also protected by domestic barriers. The combination between captive suppliers and protected customers is not the appropriate environment for innovation. When the service economy exploded, in the 1980's, the US service sector was ready to capitalize on at least two decades of experimentation with IT. When the two main breakthrough innovations in IT were introduced - the PC in the 1980's and Internet in the 1990's - these companies were ready to implement them into operations.

Is this perspective, there is a clear explanation for the increase in productivity. It is not mainly because workforce is flexible that US service companies are more productive. It is because they have heavily invested into IT since long that workforce finds it socially acceptable to push productivity. Without IT, the increase in productivity in front line operations can only be achieved by increasing the work hours or deteriorating the working conditions.

This long explanation introduces the following point: if this argument is correct, then an increase in the quality of research in Europe will have a large impact on growth due to larger pool of selection and other factors outlined above. In particular, by fostering R & D for Societal Challenges, there is some chance that new IT solutions can be developed and implemented in the service sector. In areas such as info mobility, urban congestion, transport, healthcare, energy management, new solutions will likely be implemented by the service sector, not the manufacturing one. In turn, the deployment of new service solutions will benefit both software and hardware industries in Europe, as well as other manufacturing sectors.

If Europe has learnt the lesson from past errors in policies towards IT and services, such as the protection of national champions and the fragmentation of national service markets, the gap in productivity may well be addressed in the next decade.

Addressing Societal Challenges

One of the main sources of risk for private investment is the presence of negative externalities that cannot be controlled by companies. If a private R & D project fails due to technical problems, or commercial errors, it is only the company to be blamed. But often the success of innovation depends on a number of external conditions that are influenced by the public sector or by societal factors at large. Nelson has introduced the notion of 'social technologies' to include all aspects of innovation whose dynamics cannot be explained with reference to the performance of products and services, or physical technology. As he remarks clearly, the important problem is that social technology tends to evolve much more slowly than physical technology.

With Europe 2020, the European Union has made a bold decision: to place Societal Challenges at the core of its innovation strategy for the future. The relation between Societal Challenges and the need for the ERA is clear. In fact, in addressing Societal Challenges there is no room for purely national solutions.

First, these challenges require research, development, experimentation, and social testing of new technologies and organizational models on a large scale, not a small one. Changing social behaviours is only possible if people believe other people will do the same. This is sometimes called a network externality effect in the economic language. It happens that people do not only consider the intrinsic value of a solution in order to adopt it, but also the number of other people that have already adopted it. Thus, intrinsically, better solutions such as fax, mobile communications, or e-commerce were not largely adopted until people started to be persuaded that a sufficiently large number of other people was doing the same. Most Societal Challenges are subject to the same phenomena. It is not rational to give up car transport in congested cities unless most other people do the same, so that public transportation becomes timely and comfortable. It is not convenient to shift to electric cars until the network of distribution of electricity becomes sufficiently dense to eliminate the risk of going short of energy. These formidable network externality effects may prevent any change to take place, if insufficient momentum is placed in the implementation. Therefore the only scale at which change may take place is a large one, that is, a European one.

Second, due to the uncertainty associated to these challenges, it is important that multiple experimentations are tested in parallel, because there is no certainty on which solutions is preferable. Thus, for example, wind energy solutions have to be tested in multiple environments and locations, because the engineering specifications must be optimized differently. Or solutions for elderly care have to be experimented within different health and welfare systems. Again, this is not feasible within individual Member States.

Finally, as the discussion in the previous section has shown, the lack of competition in services across Europe causes a lower rate of return of that private investment in R & D also in the upstream manufacturing sector. The only way to address Societal Challenges is to address the need for new solutions with a pan-European approach on both sides - opening markets to competition, on the supply side, and delivering solutions tested across all (or many, at least) European countries, on the demand side.

But how can new societal goals be achieved if the respective research agendas are left at the national level? Europe has an important opportunity to regain world leadership in areas where innovation is hampered by the need for social adaptation. It must be considered that, while most service sectors in which the gap in productivity between Europe and USA is large are private services, in all Societal challenges there is a mix between public and private, or a situation in which the public sector is a necessary condition for positive externalities to the private sector.

Here the European countries do not have yet a gap in productivity of services, but on the contrary, they may become the leaders at world level. Due to the high standards of welfare and healthcare, the good quality of urban environments, the focus on environmental problems, the experience in the careful management of energy resources, European countries are the ideal environment for developing and testing advanced solutions to Societal challenges. And many services associated to these challenges are yet to be developed. And while there will be room for many new services, there is also huge market also for the manufacturing sector.

The ERA is not a business of the public research sector alone. All researchers and research performing organizations will benefit from a larger and stronger European Area. It is also of the maximum interest for the private sector. In short, a stronger ERA is a key element for Innovation Union.

To put it clearly, it is now recognized that there is not a deterministic and linear relation between scientific performance, industrial R & D, innovation output, and growth. Any simple linear argument, of the type 'give more resources to public research and innovation and growth will inevitably occur' is discredited. The ERA is not built around a simple linear argument, as a late version of Vannevar Bush's *Endless frontier*. It is built around an articulated view of the complementarity and interdependence between science, technology and innovation.

First, in almost all knowledge-intensive sectors, while there is not a short term direct and linear relation between scientific performance and innovation, there is a powerful indirect impact, which is channelled through mobility of inventors, entrepreneurial creation, training of technical staff, creativity of students, informal relations between researchers and industry managers. The ecology of innovation is nurtured by a thriving research environment. Entrepreneurial minds are better selected and take more ambition in innovation ecologies that are fed by a continuous flow of ideas, smart people, opportunities and challenges.

Second, companies often search for cooperation from public research. In doing so, they try to balance two criteria: *research quality* and *research relevance*, or contextualization. Research quality, as expressed in scientific reputation coming from international publication activity, is a signal of the ability of the research team to contribute to the advancement of frontier. There is large evidence that companies give adequate weight to research quality in their search for partners. At the same time, international publications are not enough if researchers are not willing to contextualize knowledge, or to take industry problems seriously. Admittedly, there might be a trade-off between quality and relevance, so that the private sector may benefit also from a dedicated effort to address industry- and firm-specific (as opposed to generalizable and publishable) issues and challenges. While it is important to recognize this trade-off, it is clear that a larger Research European Area may induce a better division of labour among research actors. Creating a multi-layer, transparent and competitive funding environment means that all research teams will be able to position themselves, over time, in their better position, matching their research profile with funding opportunities. Companies will receive from the research sector more quality, but also more relevance.

Finally, there is sufficient evidence that also traditional manufacturing sectors might benefit from stronger relations with research. This is a notoriously difficult issue, due to institutional and cultural differences between SMEs - the backbone of traditional sectors, and academia. At the same time there are a number of pervasive and transversal innovations that bring the promise of renovating these sectors. Consider for example the impact of materials science in industries such as textile, clothing, construction, or yachting. Or consider the impact of information technology in tourism, logistics, fashion, or public services. Most likely, the investments in research done in the last decade are close to bring important results in terms of radical innovations and reconfiguration of entire sectors. It is important that this innovative restructuring takes place at European level.

The ERA is definitely a business for all.

III — Research projects: socioeconomic benefits of the ERA through extending competition and cooperation

A — Strengthening the ERA at the level of research projects

While the notion that the European Research Area is good for infrastructure and mobility is largely accepted, it is much less obvious why it might be beneficial at the level of individual projects, that is, priority setting, selection, funding and evaluation of research projects.

Why should Member States increase the share of their national resources they want to manage in an integrated way at the European level? Why spending 1 bn. € in cross-border programs, or in the EU budget, should be more efficient, and generate more positive externalities, than spending the same amount in the national budget?

Two answers that have been provided in the past are easy to understand: efficiency in administration, and research cooperation. According to the former argument, the main benefit comes from administrative efficiency, perhaps derived from some form of economies of scale in project administration, or professionalization of research management roles. Member States would contribute to the EU budget, compete for projects administered at EU level, but would closely monitor the correspondence between contribution and return in projects. In this perspective, an important point is how the management of research programs at the European level compares to national programs in terms of administrative efficiency, evaluation cycle time, time-to-contract, and similar aspects. This problem has repeatedly risen in past years, and is currently emphasized in positions of both Member States and stakeholders. Simplification is crucial here.

According to the latter argument, there is real value added to research at the European level, which is given by the creation of research networks, and more largely, by research cooperation.

Several evaluation studies of FPs in the past have shown this positive effect. The most important beneficial effect of creating research consortia and alliances across Member States is the creation of research linkages which would not be activated otherwise. Similarly, the experience of Networks of Excellence, in FP 6th and FP 7th has been evaluated positively in terms of creation of linkages, although probably not in terms of achievement of durable integration.

Efficiency in administration and research cooperation are valid arguments. Both kinds of benefits from integration deserve attention.

However, these benefits have already been reaped after almost three decades of European research policy and constitute a great success story of European integration.

Is this enough? Or should the ERA be strengthened only for researchers' mobility and infrastructures, leaving aside further integration at the level of individual projects? It is the suggestion of this Report that much is to be done to strengthen the ERA.

There is a need to expand the ERA in research projects in three directions:

- cross-border selection and funding of research projects
- flexible eligibility criteria
- coordination between research and innovation policies and cohesion policy.

B — Cross-border selection and funding

Although the budget for EU research has been rising in real terms, it is still inadequate to face the international competition on research, particularly from new entrant Asian countries, and to address Societal Challenges. There is a need to leverage on all available resources, including national research budgets, in a more coordinated way.

Member States claiming their national policies, including priority setting, are consistent with European research policies is not enough. What is needed is the pooling from national and regional resources in order to prioritize, select and fund cross-border research projects. Cross-border selection and funding is a dimension of the ERA, which has to be leveraged and integrated within established procedures at the European Union level.

The rationale for cross-border operations is strong:

- funding from Member States is a welcome complement to EU resources;
- it corresponds to the bottom up initiative of Member States, consistent with their national policies and with the accountability to national taxpayers;
- it is more flexible to changes in orientation of research priorities due to the emergence of unexpected technological options;
- it will increase the competition for funding, giving more resources to cross-border alliances of high quality.

It is advisable that the full integration of cross-border initiatives within the framework of Europe 2020 be achieved.

In the current legal and institutional framework of European countries, outside the Framework Programme there are two main types of mechanisms to arrange cross-border collaboration:

- money crosses borders;
- money does not cross borders.

According to the former scheme, institutions sign an agreement according to which when a research project is transferred in another country (for example due to mobility of the principal investigator), the funds follow it and cross national borders. For example, at the European level, 27 research organizations (councils, agencies, PROs) have agreed to the principle of Money Follows Researcher (MfR), preparing for the portability of grants. So far, however, the amount of money transferred has been limited. A similar arrangement is the Money Follows Cooperation Line (MfCL), whereby organizations are prepared to transfer money to research teams located in other countries (typically, up to 30% of any grant is spent in international collaborations), according to the International Co-investigator policy. In these cases, countries or regions create a real, not virtual Common Pot of funds. The 'money crosses borders' principle is easier to administer for researchers, but in some countries it suffers from a number of legal and administrative limitations. Furthermore, since reciprocity is an issue, it is subject to complex issues of negotiations, reflecting national interests, brain drain problems, wage disparities, and the like.

According to the latter principle, research organisations agree on a shared research agenda and select research projects jointly, according to agreed procedures. Selected projects are then funded separately by national organizations. For example, the Open Research Area (ORA) agreement between organizations in France, Germany, the Netherlands and UK has opened a number of calls in social sciences, pushing both competition and cooperation among the best research teams. Another example is the Lead Agency Procedure scheme. These schemes are sometimes called Virtual Common Pot.

In these cases reciprocity is not at stake, although there must be some work to standardize evaluation procedures. This scheme is compliant with almost all legal frameworks of Member States.

These experiences should be encouraged and supported in several ways. On the one hand, existing FP schemes, such as ERA-Nets and Joint Programming Initiatives, could be used to reinforce these cross-border bottom-up initiatives with substantial financial provisions. On the other hand, variable geometry initiatives could be put in place with a soft support from EU in terms of policy intelligence and coordination.

C — Flexible eligibility criteria

European research policy is currently polarized around two relatively 'pure' models of research projects.

At one extreme, we find traditional research projects funded by FPs. Here the eligibility of projects is granted only to research network, consortia or other cooperative arrangements, with a minimum number of different countries involved. Depending on the research theme, projects may be quite large, involving several countries and dozens or hundreds of researchers.

At the other extreme, we locate the new model introduced by the European Research Council. Here, no cross-country cooperation is necessary for Starting Grants and Advanced Grants, and some cooperation has only recently been introduced with the Synergy program. Individual grants are explicitly encouraged.

For historical reasons and due to the legal constraints from the Treaties, the former model has been dominant until recently.

However, high performance research systems need a variety of funding arrangements and also of organizational model. In order to cope with the sheer variety of scientific and technological fields, 'one size fits all' is not an adequate solution at all. Research fields differ enormously in terms of their requirements for cognitive, technological and institutional complementarity. Therefore the problem at stake is whether it is advisable to fill the organizational vacuum between cooperation networks and individuals.

There is increasing recognition that a full scale research policy at the European level requires more variety in organizational arrangements. There should be room for research cooperation of variable size and heterogeneity, without fixed rules in terms of number and types of countries. Also, there should be room for projects of largely different size, tailored to the problem at hand, without predefined constraints on the volume of resources. More variety should be also allowed in time, supporting initiatives whose time horizon is much longer than traditional projects, for example for the creation of collective intermediate research goods.

More variety in organizational models should be reflected in new eligibility criteria. These new organizational models could be tested preliminarily in cross-border cooperation, involving few countries that share part of their research agenda.

D — Coordination between research, innovation and cohesion policies

As it has been stated in this Report, research and innovation policies should follow only excellence criteria, while territorial cohesion policies should aim at balancing the spatial concentration of activities, following a place-based approach. Having established two separate principles, which have different objectives, it becomes important to consider how the coordination between the two can be achieved. This Report argues that coordination should be achieved down to the level of research projects, i.e. must reach the micro-organizational level.

The coordination at the level of research projects is very important, since achieving coordination at this micro-level would necessarily require coordination at higher levels of organization, i.e. in the planning and priority setting stages. This has not been done before, partially because of the narrow legal framework of European research policy before the Maastricht Treaty.

On the other hand, it must be admitted that the policy orientation towards allocating large share of Structural Funds to research and innovation is relatively young, so it has been difficult to establish horizontal coordination with other policies. This issue is now clearly on top of the agenda.

One reason is that preliminary evidence on the impact of Structural Funds on research and innovation capabilities is mixed. According to some observers, the impact on industrial R & D and company competiveness is not satisfactory. More evaluation is clearly needed here, but also more research.

If this is the goal, one should try to delineate how research projects in countries and regions using Structural Funds should be selected and evaluated. One line of reasoning follows the idea of articulating the principle of excellence according to two dimensions, absolute and relative, or prospective.

According to the absolute dimension, all research projects should be subject to criteria of excellence, whatever the country or region of origin. As this Report has argued, excellence is better promoted when the selection pool is large. In practical terms, it would be advisable to submit research proposals, even if funded with national or regional funds, to ex ante selection procedures at the European level, or at least in a cross-border framework.

This goal will be largely achieved with a European system of peer review for the ex ante evaluation of projects, using common standards, and producing common scores to facilitate comparability of merits across countries.

There are not legal obstacles for following this approach. It is largely admitted that it is not feasible for governments to transfer funds to other countries outside formal bilateral or multilateral agreements. Certainly it is politically prohibitive. On the contrary, there is no compelling legal argument for the notion that the ex ante evaluation of research proposals is only a national prerogative and that national funds cannot be allocated based on evaluation practices carried out at international level. *Box III* offers a remarkable example of complementarity between excellence and cohesion.

This approach has an important positive implication for catching up countries and regions. One of the most serious issues, in fact, is the difficulty in preventing brain drain of the most talented researchers either to non-research careers or abroad. Using Structural Funds in a clever way is the best solution: for example it can be stipulated that those research teams that are able to excel at the European level may benefit from extra resources, in addition to research money. One important direction is given by research infrastructures, which could be funded with Structural Funds. If placed within the overall framework of ESFRI, these infrastructures could offer a robust argument for talented scientists to stay at home, nurturing generations of students and researchers for the good of the country.

According to the relative or prospective dimension of excellence, cohesion policies should consider the relative position of the research system in the international context. It is not realistic to assume that all parties of the research system could compete at international level. What can be done, however, is to select a number of fields (at whatever level of granularity) that could compete within a reasonable time horizon, and to invest into human capital and capabilities. This should be done, however, by defining clearly visible intermediate results, in the medium and long term, and by using systematically external reviews to steer the research system.

Box IV: How to combine excellence and cohesion

An interesting case of complementarity between excellence and cohesion is visible in the Energy field. In 2008 the SETplan was established at the European level, as a 'first step to establish an energy technology policy for Europe'. It is based on long term technology goals, extending from 2020 to 2050, articulated in European Industrial Initiatives (EII), which involve industry, research, Member States and the Commission.

The SETplan is supported by the European Energy Research Alliance (EERA), which aims at the alignment between research agendas and at building up a framework for joint programming, and promotes the realization of shared technology roadmaps.

With respect to the coordination between Member States and EU, the following options have been considered by the SETplan Secretariat:

A. Coordination/ synchronisation of national projects with an EU 'glue'
B. Coordination/synchronisation of EC and MS calls for proposals and/or families of projects
C. ERANET (+): joint calls between EC and MSs
D. Joint MSs funding of EC Framework Programme (FP) Reserve List Projects
E. Joint (co-funded) EC-MSs projects (Third party financing of FP projects)

With respect to the option C, two ERANET+ programmes are under preparation, on Concentrated Solar Power (CSP) and Photo Voltaic (PV) technologies. The programmes will involve at least three countries; will be led by consortia of funding agencies and/or ministries. Proposals will be selected according to ERANET standards and governments will fund only the winners in their country (so called 'virtual common pot').

What is remarkable is that in 2011 two Italian convergence regions (Puglia and Sicily) have joined this initiative by allocating Structural Funds to its preparation. Under this scheme, companies located in the respective region will be funded only if they survive the European competition. According to the Regional governments, this will motivate the local industry to compete at a European scale, with large expected spill-overs.

Needless to say, there are many others goal for cohesion policies, that may involve directly or indirectly the research system as a key actor. These include education, targeted applied research as a support to domestic industry (even at low to medium technological level), or technology transfer. What is crucially important is that these goals are articulated clearly, with objectives and indicators that are different from those of excellence in research.

In most practical situations the research system will have an overload of missions and tasks, particularly in the university sector. The pressure on research excellence will coexist with the urgency of addressing large scale educational needs (or building human capital) and supporting the third mission to enhance opportunities for growth. But nonetheless it must be left to research actors to identify their best profile and to manage the trade-offs between different missions. On the policy side, there must be clear distinction between the excellence principle and other legitimate principles.

IV — Researchers: socioeconomic benefits of the ERA through researchers' mobility and collaboration

A — Socioeconomic benefits of the ERA through researchers' mobility

The empowering of human resources in science and technology in the context of the ERA

There is virtually unanimity among academics, analysts, policy-shapers and policy and political decision-makers that human capital has a critical and decisive role in promoting the knowledge economy and society in Europe. In particular, the availability of highly skilled scientists, engineers and researchers constitute a strategic core factor for the Science, Technology, Innovation and Diffusion System at all different levels (regional, sub-national, national, continental) and can act as a driver for innovation, growth and job creation. Researchers and knowledge workers in Europe, as prime carriers and conveyors of knowledge (both codified and tacit), represent a critical element for facing the challenge of increasing global competition in the era of growing globalization and the rise of the knowledge economy. European firms face growing competitive pressure in the context of globalised markets from companies located both in the US and Asia, as well as other non EU countries. Moreover, China and India have started building a science and technology (S&T) system with a skilled scientific, engineering and technical workforce capable of generating new knowledge and developing innovation (Hansen, 2009). They attract business R & D and it is expected that, by the year 2025, they become the main destination for the location of business R & D (European Commission 2009b).

The only viable response should be pursued via innovation-based high-quality strategies i.e. the creation and use of new knowledge related to products, processes, organizational schemes, business models and markets. In this respect, highly skilled and competent researchers and the existence/ creation of high quality research groups play a critical and defining role for: a) improving the efficiency and effectiveness of the research systems (i.e. at national, regional and continental level) across Europe, b) strengthening Europe's position in the global research landscape - as Asia catches up and challenges the scientific and technological supremacy of the traditional world powers in S&T activities (European Commission 2009b) — thus enabling Europe to remain as a relevant global player in a knowledge-based economy and society, and c) enhancing the ability of the Science and Technology System in Europe to deliver gains to the economy and society in terms of innovation, growth and meeting societal challenges.

But, the creation, maintenance and development of an internationally competitive research system in Europe depends predominantly on the ability to inspire and motivate young scientists and engineers in all European countries to consider employment in research activity as a desirable and feasible career path option, to attract leading as well younger talented scientists from all over the world to get engaged in a research career in Europe and to create the conditions, the instruments/ mechanisms and the mentality for recurrent mobility and temporary exchanges of researchers within Europe and to countries outside the EU at intra-sector-based or/and inter-sector-based level. Furthermore, in this regard, it is absolutely necessary to attract and retain in the research profession more women in order to unleash and fully utilize the existing untapped potential of human capital in Europe and broaden the skill base of the research system in terms of variety and dynamism.

Overall, international mobility of doctorate and post doctorate students, researchers, academics and highly skilled engineers and scientists is generally considered to bring about positive effects on both the researchers/scholars and on their environment.

A fully functioning ERA presupposes an adequate flow of competent researchers with high levels of mobility between institutions, disciplines, sectors, regions and countries. In this context, geographical mobility should be supplemented with thematic and functional mobility both across Europe and also within the same country or region (i.e. from research to industry, from research to setting up a new entrepreneurial venture, from university to a public research centre or vice-versa, from research to policy-making, from a policy-shaping / making institution to another). Inter-institutional mobility or/and collaboration enhances the capability of European Research System as a whole and at different levels to overcome segmentation and fragmentation, and enhances the capability to connect distributed knowledge, skills and competencies, which seems to be particularly important for emerging domains (i.e. nanosciences, mobile applications). Mobility of researchers between academia and industry lies at the heart of inter-sectoral mobility and constitutes a very important component of a fully functioning ERA. It should be considered as 'a means of enhancing a culture of longer-term, structured interaction and cooperation between both sectors in terms of knowledge transfer and development of cross-sector skills and competencies' In this respect 'it can contribute to eradicating the so-called European Paradox' and at the same time 'it adds to the employability and diverse career development of researchers' (European Commission 2006, p.8).

Thus the promotion and development of the ERA means that actors involved in research activity and research policy (researchers, research teams, research organisations, business firms as well as regional authorities, Member States governments and Europe as a global player) can broaden their capabilities and potential both for performing research and exploiting research results. In particular, the ERA's specific targets for mobility of researchers, and for research collaboration as complementary to mobility as well as an alternative path, can empower research actors and enable them to broaden their research horizon and exploit new / additional strategic opportunities. In this respect, providing support for building innovative and well functioning networks of research units across Europe can be considered as an important element of the ERA. It is in this spirit that the promotion and expansion of the ERA can deliver concrete benefits for European researchers and the research activity in Europe. In addition, attracting talented young people and senior researchers from different parts of the world is a critical factor in developing a globally competitive ERA by enhancing the human research potential in Europe and ensuring access to knowledge in global networks.

What do the facts actually say about mobility of researchers in Europe and the globe?

There is limited availability of statistical information on researchers at the European level. Trends on mobility are currently calculated only for the population 'Human Resources in Science and Technology Core' (HRSTC) which is used as a proxy indicator for researchers. This population consists of the whole spectrum of S&T professionals and is considerably larger than that of researchers; however, there are no data on the part of the HRSTC that conducts research (European Commission 2008). An obstacle to detailed analysis on research mobility within Europe and between Europe and other countries is not only the lack of internationally comparable data and statistical information on researchers, but also the fact that national sources are scattered and contain limited information (Inzelt, 2010). The most available data are those pertaining to doctoral students (young researchers).

According to an EU Report (European Commission 2008) the mobility of professionals in S&T has increased rapidly over the period 2000-2006. However, precise and detailed data on the mobility of researchers at geographical and sector-based level are missing. The UK, Austria, Belgium, Denmark and the Netherlands have the highest shares of foreign researchers. The largest intra-EU flows of mobile researchers are observed between the five largest EU countries and in particular to UK. The increased mobility of S&T professionals inside the EU can be partly attributed to an effect of the overall globalization of research rather than that of European integration as such, since the mobility growth of non-EU S&T professionals has exceeded the mobility growth within EU. The same conclusion can be drawn for doctoral students. In 2005, 6.9% of the doctoral candidates in EU-27 had the nationality of another EU country, while 14.1% had the nationality of a country outside EU.

According to the OECD STI scoreboard 2009, Europe's performance at a global level on hosting doctoral students is far lower than that of the US. More specifically, the United States hosted the largest foreign doctoral population, with more than 92,000 students from abroad in 2006, followed by the United Kingdom (38,000) and France (28,000). This is a clear indication of the international attractiveness of US universities and the extent of research opportunities offered.

Box V: **Mobility of researchers in Europe: Some stylized facts**

- Among doctorate candidates in the EU: 7% are Europeans studying in another EU country, 17% are citizens from countries outside the EU and 76% are EU nationals studying in their own country. These figures indicate that mobility is still limited across Europe.
- The UK, Austria and Belgium host the highest percentage of doctoral candidates from other EU Member States. In relative terms Portugal, Bulgaria and Slovenia are the biggest exporters of doctoral candidates to other EU member States, while the UK exports the lowest share of doctoral candidates. Thus, there is an uneven spread of research mobility across EU countries.
- More than half of all researchers employed in EU-27 HEIs (Higher Education Institutes) have experienced international mobility at least once during their research careers.
- Much HEI researcher mobility involves shorter or longer term research visits (not involving a change of employer) to research institutions, collaborators or facilities (RIs) elsewhere. Researchers in the Southern European countries are most likely to be internationally mobile at least once in their career.
- The number of European citizens receiving their doctoral degree in the US is still relatively low (2-3% of the total number of doctoral degrees awarded in Europe) despite the significant increase (almost 40% in the period '1996-2007'). It is also worth mentioning that Greece, Bulgaria and Romania are the MEMBER States with the highest share of doctoral students that have finalized their doctoral degree in the US.
- Chinese students are the most important non-European pool of doctoral students in the EU.

Drawn from the More Project on Mobility patterns and career paths of EU researchers (IDEA et. al. 2010)

Benefits from mobility and potential trade offs

In general, benefits from mobility can be attributed to a) interaction and learning by interaction, b) potential positive externalities from knowledge spill-overs, and c) direct and indirect impact of knowledge diffusion. These potential benefits can be realized through mobile people/ talents. In this context, mobility can be identified as geographical and inter-sector-based. Mobile researchers engaged in geographical mobility constitute a significant resource pool which can contribute to the competitiveness of a country, a region or a firm by:

- Improving the R & D performance at the national, regional and firm level,
- Integrating domestic actors into international RTD Networks,
- Providing knowledge for the creation of new entrepreneurial ventures.

But, mobility constitutes both a threat and an opportunity for a geographical area (embracing several nation-states and even entire sub-continents or subdivisions of nation-states) and/or economic/ social actors/ organisations (firms, research institutions, university research groups etc.), since the knowledge base of a geographical area or an organisation can be strengthened by inward mobility but weakened by outward mobility. Nevertheless, even in the case of outward mobility the sending or 'departing' area/ region and or actor can benefit from the mobility of its researchers/ knowledge workers through potential networking, future cooperative schemes and knowledge transfer activities.

Mobility: Benefits for whom?

Mobility is not an end by itself. Mobility brings about specific benefits for individual researchers. In general, the intra-European and/or international mobility schemes increase the possibility for enriching the personal research agenda of the mobile researcher, thus contributing to his/ her career development and career progression. Mobility per se improves the academic CV of a researcher. More specifically, mobility provides concrete benefits to individual researchers by 'plugging' the mobile researcher into a wider network of contacts in the scientific community (networking and maintenance of network contacts), and enhancing the potential visibility of his/ her scientific work through the dissemination and diffusion of findings via a 'network of networks' of contacts and joint publications. Moreover, it allows for the exposure of researcher to different research environments and research practices which enables him/her to create new insights and new perspectives for his research activity. In addition, mobility allows for the sharing and transferring of knowledge, skills and techniques (codified and, mainly, tacit knowledge), thus establishing complementarities between International Mobility of Researchers (IMRs) and Knowledge and Transfer of Technology (KTT) activities. Furthermore, mobility allows researchers to have access to improved facilities and infrastructure and creates for them the prospect to work with leading experts. In this regard but also in general, mobility enhances the efficiency/ effectiveness of researchers in terms of publications, as it appears that in general mobile researchers are more productive. Finally, mobility through open recruitment (associated with the promotion of the ERA) in particular expands the career opportunities for individual researchers.

Mobility: Not 'one size fits all'

Mobility patterns, career paths and the effects of mobility on individual researchers as well as on research organisations, etc., can be better analyzed, measured and assessed when specified to different groups of researchers and different types of mobility. In addition policy measures can be better targeted with regard to specific distinct groups of mobile and candidates for mobility researchers. In this context, the following taxonomies based respectively on the type of institution, the career path of the researcher and the type of the mobility can be adopted:

Groups of Researchers (by type of institution)

- Researchers working in Universities and Higher Education Institutes (HEI),
- Researchers working in Public Research Institutes (PRIS) [non-University Institutes],
- Researchers working in Industry.

Groups of Researchers (based on the career phase of the researcher)

- Researchers in training phase (Ph.D. students),
- Young Researchers in professional/ employment phase (including post docs),
- Senior Researchers in professional/ employment phase.

Types of Mobility

- Geographical Mobility (both across Europe, and between EU and non EU countries),
- Job/sector-based mobility.

As it was found in the MORE study (IDEA et. al. 2010) 'the profile of industry researchers differs from academic researchers in a number of ways' in terms of personal characteristics, education background, work contract and career path. In addition, industry researchers differ substantially in their mobility both from academic researchers and among themselves. More important at least in some fields is the mobility of a researcher from academia to industry and vice-versa.

In addition, the duration of mobility appears to be of particular interest, especially for those researchers that are departing from less developed — in terms of scientific research activity and performance — areas and they are not willing to disconnect themselves from their research institution in their home country. In this case they might prefer shorter but more frequent visits. In addition senior researchers might also prefer shorter visits. In this context, it is very important to distinguish between different types of mobility in terms of the time-period spent in the visiting institution. In this regard one can distinguish between temporary or/ and recurrent mobility materialized through short research visits (1 to 3 months) and longer ones (1 to 3 years) and mobility leading to a permanent research position in another region/ country or to a dual appointment (migration or cross-border working).

Again, the effects of mobility should be specified in relation to different actors, thematic area/ sector, duration of mobility, geographical area, types of output (publications, citations, patents) and network effects, i.e. effects on professional experience, access to international network of researchers, access to infrastructure.

Mobility: Influencing factors

Mobility in different forms is influenced by a range of factors. An attempt to group them can lead to three types of main influential factors, namely:

- Personal motives (personal and cultural).

- Profession-related motives (career progression goals and personal research agenda).
- Practical influencing factors (administrative and non-career/ profession related factors).

Any policy aiming at increasing mobility of researchers should deal very cautiously with these factors.

For mobility in general, various regulatory obstacles in the areas of social security and taxation hinder a more frequent mobility and particular a built-in structural type of mobility throughout a researcher's career i.e. for establishing mobility as an organic feature of the career path of European researchers. Existing regulations, organizational structures, local habits and cultural factors, sometimes constitute formidable barriers to change and hence to mobility. In practice, mobility is slowed down because of differences in incentive systems, search and mobility costs, asymmetric information as well as different cross country contexts in terms of existing national regulatory regimes. In addition, migration has a cost for the mobile researcher/ scientist both in monetary, family, psychological and career terms. Many migrant scientists (researchers) face a difficulty to return at a later stage of their career to their home country, as by that time and at that stage of their careers the system is closed for them, as they are considered as 'outsiders'. In this context mobility is very much related with the age of researchers ('you are mobile when you are young and from a certain age you settle down'). Also, different and not harmonized pension and social security systems in different countries hamper mobility of researchers. In sum, a number of legal and practical barriers hamper researchers' mobility across institutions, sectors and countries. At the same time, career incentives (interaction with high quality research groups and leading researchers, access to research infrastructures, opening of future cooperation, exchange of research visits, joint publications) associated with economic incentives drive mobility. In addition, cross-border Pension Fund for Researchers may facilitate the mobility of researchers (i.e. the pension rights of researchers would not be lost).

It should be mentioned that although the recruitment in many EU Member States is already open in legal and administrative terms, the practice in most cases remains local/ national. This goes hand in hand with the practice of in-breeding. In other words recruitment is formally open, but practically not to a considerable extent because of in-breeding. Academic in-breeding is considered as a recruiting practice which can be damaging to scholarly output. Furthermore in-bred faculty can be less open to the rest of the international scientific community. In this regard, mobility of researchers can improve the level of information on the quantity and quality of the supply of scientific personnel in specific thematic areas and disciplines across Europe, and thus broadens the selection pool in recruiting research personnel.

Mobility as perceived by the research community: Some empirical evidence

Mobility, along with researchers' careers, is considered by the majority of respondents (four out of five) to the ERA Framework Public Consultation as 'the most important area in which the EU should step up its efforts most urgently in order to achieve the ERA by 2014' (European Commission, 2012b). In addition, three key messages are conveyed. First, 4 out of 5 of the respondents point to the need 'to attract and retain more leading researchers and to provide all researchers with better skills particularly for the business sector'. Second, 'four out of five of the respondents believe that the working conditions and career prospects of public sector researchers are less attractive than those of other professionals with similar qualifications'. Third, it appears that 'a range of factors hamper internationally mobile researchers who, in addition, face difficulties to move between sectors'. Among them 'the lack of portability of publicly-funded grants is the most important impediment, while the lack of open and transparent recruitment procedures is regarded as one of the main barriers to international mobility'.

The recent MORE Study (IDEA et. al. 2010) provide some findings on the 'perceived effects' by the individual researcher as well as on the factors influencing the mobility decisions of researchers (barriers to mobility, personal motivations to become mobile) for two distinct groups i.e. academic researchers and industry researchers. More precisely, for academic researchers the practical influencing factors (administrative and non-career/ profession related factors such as the social security system, administrative barriers, language issues, childcare, etc.) do not seem to play an 'important' role in their mobility decision. But, as it should be expected, female researchers assign higher importance than males to childcare arrangements, which are more important for the non- mobile researchers, thus possibly constituting a potential barrier for mobility. Regarding industry researchers, nearly all practical influencing factors are important and they are considered as most important barriers for the non-mobile industry researchers.

Finally, a third study (Ivancheva and Gourova, 2011) investigates the positive effects of international mobility schemes, concerning the researchers and their careers as well as the national research systems and the ERA as a whole. This study is based on a survey in 8 European countries (Austria, Bulgaria, CYPRUS, Czech, Greece, Hungary, Slovakia, and Switzerland) and supports the view that 'the national actions did not create a homogenous environment and researchers face various problems when moving between countries'. Furthermore, it emerges from the comparative survey analysis of 8 European countries that it occurs 'a strong willingness and professional motivation to participate in international mobility programmers, regardless the major economic differences between the investigated countries'. Besides, 'international mobility is considered as an important factor for future career development in research'. But, 'short term mobility programmes and schemes are preferable', while in the majority of cases the last destination was another EU country'.

Priority actions to foster mobility of researchers

Since mobility of researchers is recognized probably as the relatively most important dimension of the ERA, a number of priority actions concerning mobility should be activated. It is essential to:

- promote systematically open recruitment,
- institute portability of grants (adoption of 'follow the researcher' schemes),
- meet social security and supplementary pension needs of mobile researchers,
- provide attractive employment and favourable and creative working conditions for mobile researchers,
- enhance the training skills and experience of researchers,
- adopt specific measures to better allocate the cost of migration of mobile researchers. In this regard, the 'notion of package' could be introduced in the recruitment process, related to providing supplementary offerings for other family members (job opening for spouse, schooling for children, accommodation, etc.) the way it is practiced in the US. In this case, the cost of migration is absorbed to a certain extent by the University. In more general terms you need to create a system which bears part of the cost of mobility.

The risks of mobility: The brain drain effect

But still mobility - in particular permanent mobility - is associated with the risk of brain drain for the sending region or country. Thus, a key tension arises between mobility and cohesion. The occurrence of brain drain harms the research effort in less favoured regions of Europe. It can weaken or even disrupt the research team of the mobile (emigrant) researcher in his home country. In addition, it can undermine the position of the temporary mobile researcher- who leaves for a longer period (three to five years) and is willing to return back - in the research community of his home country as at that time he is considered as an outsider. Nevertheless, mobility can be seen at the same time as a driver for excellence (larger base for the selection of scholars) and a driver for convergence through Knowledge Transfer activities and networking.

Moreover, the brain drain effect should be mitigated through relevant policy measures which promote instead brain circulation. Besides, brain circulation is fully compatible with the vision of the ERA, as 'it was assumed that the creation of an 'internal market' for research would help to keep the outwardly-mobile EU academics in Europe, including star scientists, draw expatriates back home and attract excellence into Europe from third countries' (Inzelt, 2010). In addition, a cohesive ERA needs to promote and accelerate brain circulation between countries and sectors within Europe. In the framework of a brain circulation research effort both outflow and inflow programmes are needed. Outflow programmes for researchers and students - especially outward mobility of young researchers - both of a general purpose and in selected fields can upgrade home-country capabilities and enhance networking. In addition inflow programmes - especially inward mobility of senior researchers as well as encouraging and supporting returnees for relocation and reintegration in their home-country - can attract scholars and students from other EU and non EU countries.

The effective transition from a situation of 'brain drain' to a more balanced regime of 'brain circulation' can be positively influenced by promoting specific complementary activity and relevant policy measures. The way the education and research system (in different countries and regions) works can create (or block) the conditions for building these necessary complementarities. In this respect, complementarities between postgraduate education and research programmes are crucial. Furthermore, mobility should be considered not only at the level of the individual researcher but also at the institutional level. The benefits of mobility of researchers should be spread across institutions and should not destroy already existing or emerging research groups in a number of regions. Last but not least, in countries, where a strong non University system of public research institutes coexists with the University system, a more or less clear division of labour between 'programmatic long-term research' (conducted in the public research institutes) and 'contract shorter-term research' (conducted in Universities) could establish a misalignment of incentives (i.e. in terms of different promotion criteria) which in turn can lead to a 'brain-drain' effect from Research Institutes to Universities.

Finally, it is worth mentioning that in the near future a shift might occur from today's 'brain drain' to the US and Anglo-Saxon countries towards a more balanced 'brain circulation' of young researchers between regions of the world (European Commission 2009b).

B — Socioeconomic benefits from European Collaboration in R & D

Research Collaboration can be considered as a complementary (mobility with collaboration) or even an alternative path to mobility (mobility within collaboration).

The ERA promotes research collaboration at the institutional, disciplinary, cross-sector, cross-border and the European level. As modern research is more complex and requires a wider range of skills, disciplines, talents and capabilities, research collaboration brings about specific benefits for individual researchers as well as for the research activity. Increasing the European collaboration provides synergies at a higher level and at a wider range, thus increasing up to a certain point the probability of reaping the benefits of research collaboration.

Types of benefits in Research Collaborations

Following Katz and Martin (1997) there are several types of benefits to individual researchers from collaboration.

The first type of benefit from collaboration is the sharing of knowledge, skills, and techniques. If two or more researchers collaborate, the probability of possessing between them a wider range of resources, techniques, skills, etc. is far greater. Furthermore, through a better division of labour, collaboration ensures a more effective use of the individual collaborators talents. A second type of benefit is the transfer of knowledge or skills. This benefit is closely associated with the benefit of sharing (first benefit). Thirdly, collaboration may foster the creation of new insights, perspectives and scientific areas (interdisciplinary). Collaboration offers the ground for clash of views and for scientific debate leading to the cross-fertilization of ideas, concepts, arguments and interpretations. A fourth type of benefit is the 'plugging' the researcher into a wider network of contacts in the scientific community. Finally, collaboration can enhance the potential visibility of scientific work (dissemination and diffusion of finding s through a 'network of networks of contacts').

Overall, research collaboration - and in particular at a European level - can increase the effectiveness of the research effort. However collaboration implies some additional costs.

Benefits from research joint ventures and from EU-funded research collaboration

The literature on Research Joint Ventures has indicated a long list of potential benefits to cooperative R & D (Caloghirou et al. 2004)

Potential benefits to participating organizations include:

- R & D sharing,
- Reduction of R & D duplication,
- Risk sharing, uncertainty reduction,
- Spill-over internationalization,
- Continuity of R & D effort, access to finance,
- Research synergies,
- Effective deployment of extant resources, further development of resource base,
- Strategic flexibility, market access and the creation of investment options,
- Promotion of technical standards,
- Market power, co-opting competition,
- University and research institute research better attuned with private sector interests.

Cooperative R & D also creates social benefits to non-participating organizations and the rest of the society. Social benefits result from:

- Knowledge spill-overs to non-participants,
- Increased industrial competitiveness,
- Increased levels of competition,
- Favourable changes in investment behaviour,
- More efficient establishment of technology standards,
- Broad socioeconomic benefits as a result of structural adjustment,
- Increased economic cohesion between European regions.

The FP programmes seem to have a role in the promotion of common technical standards and the share of costs and risks inherent in new technology development (Caloghirou et al., 2004).

However, the most important beneficial effect of creating research consortia across EU countries is the creation of research linkages that would not be activated otherwise. Some empirical research on the networking activity and innovation impact of EU-funded research in the context of FPs provided below is revealing on the extent of the networking activity attained and the impact of research projects on changing the participating entities behaviour rather than producing readily marketable outputs.

Even though EU FPs have attracted a lot of research and evaluation studies, the nature and structure of the EU-funded research joint ventures, especially at the actor level, have been barely studied to date (notable exceptions are Breschi and Cusmano, 2004; Roediger-Schluga and Barber, 2008; Protogerou et al., 2011) mainly due to the difficulty in obtaining suitable data. All three studies indicate that EU-funded research activity has been characterized by a considerable growth in terms of participating entities and participations across Framework Programmes resulting in substantially large networks (creation of critical mass). They also confirm that the research collaboration networks emerging from projects funded by EU-FPs are substantial in terms of size and complexity and exhibit a small world property i.e. they can be assumed as networks that are effective both for the creation and the diffusion of knowledge, especially when complex and difficult to absorb knowledge is at stake (Watts, 1999, Verspagen, 2006). However, at the same time this structure can be interpreted as a consequence of the rules/patterns governing the participation in research joint ventures (Breschi and Malerba, 2009). Finally, research networking at the country level has become more intensive though time and highlights a shift from projects dominated by just a few core countries and relying on geographical proximity to projects with a more balanced national representation, therefore a strong cohesion effect is present (Protogerou et al., 2011).

An empirical study on the networks funded by FPs in the area of Information Society Technologies (IST) (Protogerou et al., 2010 a) indicates that although these networks appear to facilitate the creation and dissemination of new knowledge we cannot make a conclusion about their innovative performance in terms of direct marketable outputs. Therefore the essential result of these projects may be the production of intangibles, know-how and learning, in other words their output may be mainly 'behavioural' in character aiming at the improvement of knowledge, capabilities and strategies of the participating entities (behavioural additionality) (Buisseret-Cameron-Georghiou, 1994).

Case study analysis conducted in Greek firms (Protogerou et al., 2010 b), research institutions and universities with high participation intensity in the IST

FP6 network indicated that the value of IST-RTD networks lies for the most part in the learning effects that occur between partners and the impact that these may have on their capacity to innovate in the future. Their participation in IST networks has contributed positively to the identification of promising opportunities in the Greek market. However, the diffusion of the innovative results and knowledge acquired through the participation of Greek organizations in these networks could be further improved by national policies supporting innovation deployment.

The Innovation Impact Study (Polt et al., 2008), which concentrated on the factors that influence the extent and speed of commercial exploitation of results of cooperative R & D funded by the 5th and 6th FPs, also showed that although FPs seem to have a significant impact on innovation output, their direct effect in the sense of supporting quickly marketable research does not seem to be their defining characteristic. This practically means that although EU-funded research projects have had a significant impact on innovation this is mainly and indirect one (behavioural additionality). In short, this kind of impact makes the actors more involved in R & D activities and its focus is on building innovation capabilities and competence in general (e.g. by fostering the participating firms' ability to make use of new technologies and R & D procedures).

A study in the context of the AEGIS project examining the EU-funded research networks in three emerging IST areas in the course of a 12 year period, indicates that these networks can foster the advance of new industrial activities by bringing together key actors with different technological backgrounds and knowledge (large firms, small and medium-sized firms, universities and research institutes) necessary for the development of these activities. Moreover, by examining the network role of firms and the collaboration patterns they develop with multiple partners the study also shows that these emerging networks can be assumed as loci that foster knowledge-intensive entrepreneurship i.e. allow firms, especially small ones, to have access to an increased amount of diverse resources and even assume central roles in certain technological areas and therefore help them increase their entrepreneurial performance and outcomes. Another study in the context of the AEGIS project examining the position and role of knowledge-intensive start-ups (i.e. firms set up between 2002 and 2007) in EU-funded research networks indicates that these companies are embedded in networks where they can have access to a large amount of resources (technological knowledge and information) held by actors exhibiting a high degree of diversity (in terms of type, sector and centrality position) i.e. networks that can promote entrepreneurship performance and outcomes. Moreover, although these firms are primarily cooperating with other peripheral actors, they can also get into the network through their connections with organizations holding very central network positions. Thus, on the one hand, they can be considered as attractive partners to large incumbents due to their specific technological competences and knowledge. On the other hand, their cooperation with leading firms/organizations allows them to have access to fundamental resources i.e. an important element for determining their entrepreneurial outcomes especially in highly competitive environments.

V — Research infrastructures

Research Infrastructures (RIs, both physical and digital) in the European territory constitute one of the main 'building blocks' for the creation and functioning of the European Research Area. Thus, the promotion and implementation of the ERA means jointly planned and exploited research infrastructures for the benefit of the research effort undertaken in Europe as well as for improving the performance (both in terms of efficiency and effectiveness) of the European Research System at different levels (EU, national, regional). Furthermore, the development of a networked fabric of world-class research infrastructures contributes to promoting Europe as an attractive place in the globe for researchers and research activities.

In this context, it is necessary to distinguish between the different benefits for different actors (researchers and research organisations, students, industry, public administrations, Member States, regions and citizens) stemming from jointly designing Europe's major research infrastructures, jointly funding (but not necessarily through the EU budget), closely linking and networking them, and sharing the services provided by facilitating international access to them.

A — Arguments for the ERA at the research infrastructure level

Large-scale research infrastructures require sizeable investment and, generally, entail high operating costs. Therefore, these research facilities are often beyond the resources available at national and regional levels and can only be constructed through international collaboration. Disciplines such as physics and aerospace are striking examples of scientific fields in which large-scale research facilities play a crucial role.

Some evidence on the critical mass of financial resources needed for the development of large-scale facilities is given below:

- A recent study in the context of the ERID-Watch project estimates that the number of research infrastructures of significant size (medium and large-scale) currently in operation in Europe is between 250 and 400. The study concludes that these research infrastructures represent an initial investment (construction cost) of about €21.4 to 33.1 billion and annual operating costs of €7.9 to 9.4 billion in 2006, including the European Space Agency (ESA).
- Another survey developed by the European Commission and the European Science Foundation was conducted among 598 (small and medium-scale) RIs of pan-European interest, covering nine major fields of science. The estimated average minimum construction cost per facility amounts to approximately 60 M€. However, the construction cost varies greatly between scientific domains. 51% of them have construction costs below 20 M€ and only 5.2% of RIs have a construction cost greater than 500 M€. The most widespread yearly operational cost of an RI in each domain is in the range of 1-10 M€. Approximately 80% of these facilities are located in the EU-15 and 50% in the 4 largest Member States (Germany, France, Italy and the UK). Only 9% of the research facilities are located in the New Member States (European Commission – European Science Foundation 2007).
- A conservative estimate of the total development cost of the RI projects included in the ESFRI (European Strategy Forum for Research Infrastructures) roadmap amounts to nearly 20 B€, and, on average, 2M€ will be required annually for their efficient operation (ESFRI 2009). Under the present difficult economic situation, ESFRI projects are facing different challenges in raising the necessary funding for their realization.

Another type of research up-scaling related to large-scale infrastructures does not involve the development of a single RI but networking (e.g. in disciplines such as astronomy and biology, social sciences and humanities) through the development of complex, linked research infrastructures with the aid of information and communication technologies (ICTs). The network of researchers developed by collaborating within a linked infrastructure generates far more research results than could ever be produced by all the individual groups together i.e. by creating network effects. Furthermore, connecting up infrastructures located in different countries/national contexts makes complementary/diverse data accessible and allows the conduction of statistically reliable comparative research at a Pan-European level, thus opening up new research possibilities especially for Social Sciences and Humanities.

The interconnection of diverse RIs distributed in various sites would not be possible without the support of e-infrastructures. A wide range of Research Infrastructures from Human and Social Science Laboratories and Surveys, to interconnected Biomedical Sciences Laboratories, Environmental Sciences observational networks, Physical, Materials, Astronomical and Engineering Sciences accelerator, observatories etc. are all dependent upon e-infrastructures.

E-infrastructures foster the emergence of e-Science i.e. new working methods based on the shared use of ICT tools across different disciplines and technology domains. Across all research areas they play an important role in supporting data acquisition and management, access to standardized, calibrated and inter-operable data, data curation, the mining of archived data and its release to broad access (European Strategy Forum on Research Infrastructures, 2011).

However, not all research infrastructures are large and have physical substance. In any case, the development and management of access to RIs, either for their operation or for sharing their research functions is important for their value as research resources. The full spectrum of e-infrastructure (computing, data, networks, software, and relevant competences) that supports open access and resource exchange and pooling associated with the development of the ERA can turn Europe into a more research friendly environment, make possible the more effective use of the research potential RIs offer and open up possibilities to widely promote both pan-European and global collaboration. Resource sharing and pooling does not directly produce scientific output, but produce 'intermediate collective research goods', i.e. goods that are used by other researchers to improve research productivity.

Distributed large-scale facilities and virtual facilities (e-infrastructure) can also contribute to the integration of Europe giving the opportunity to smaller and less research-intensive countries to participate into the ERA and enabling them to profit from the wide range of competencies across Europe.

B — The added value of research infrastructures

The processes of developing, constructing, and sharing large-scale infrastructures are complex and costly. Yet RIs may play an important role in further developing and implementing the ERA through:

- benefits resulting from their existence,
- benefits created to their hosting countries or regions,
- and benefits for their national and international users.

Large-scale RIs have potentially strong impacts on science, human and social capital, economy and society.

Benefits for science

Firstly, the benefits related to the existence of large-scale RIs have to do with the advancement of science, the exploration of boundaries of knowledge, and therefore, the generation of scientific innovation. A lot of pioneering scientific research could not take place without large-scale facilities because a) large and unique facilities can perform unique experiments and gather relative data, (b) the development of complex, distributed infrastructures can increase the scope of research, c) large-scale facilities form a vehicle for multidisciplinary work, d) large-scale RIs can increase the efficiency of working in research by achieving set targets within a given period of time.

Furthermore, large-scale facilities lead to innovation on how research is organized. The use of large-scale RIs is associated to increased integration of research. Centralized large-scale research in large facilities is highly integrated because the different components are interdependent e.g. in aerospace. Networking of different instruments e.g. biobanks also implies increased integration. High integration requires greater coordination, and standardization and harmonization of research effort become increasingly important.

Finally, these facilities' use brings about innovation in the way science is managed by introducing new types of management, new sources of funding and new funding arrangements. An interesting example indicating that managing large-scale facilities demands innovation is the BBMRI (Biobanking and Biomolecular Resources Research Infrastructure) project, in which a large number of different biobanks from over 30 countries have been interlinked to create a network. The development of such an integrated international biobank network does not only involve major organizational challenges but it also presupposes reaching an agreement on complicated matters e.g. shared legal frameworks, models for public-private collaboration, policy on intellectual property, and harmonisation of quality control systems. The BBMRI project has also shed light on another point in the context of managing research, namely monitoring and accountability. The project can no longer be evaluated on the basis of traditional quality standards mainly focusing on scientific merits. The added value of such biomedical, virtual infrastructures lies in their large critical mass (i.e. the number of collected samples), biodiversity, standardisation, good accessibility, transparency, and outreach to stakeholders. Therefore 'measuring' and monitoring the added value of the RI calls for a new evaluation framework that takes into account these elements (Technopolis, 2011).

Benefits for social and human capital

Large-scale infrastructures build up various types of social networks — formal or informal, comprising of scientists alone or of scientists and non-scientists in different entities such as businesses, government bodies, various users, civil and society organizations etc. These networks are pivotal to facilitating and catalysing learning processes, collaboration, knowledge sharing and knowledge transfer. For example, RIs can be considered as important platforms around which different generations of researchers with different expertise meet and share their experience and knowledge.

Large-scale research infrastructures also act as magnets for talented researchers and provide high-quality training to young researchers and technical staff (create human capital).

Contribution to economic activity

The development (building and construction) of large-scale facilities and the procurement of related goods and services entail enormous investments that benefit local and national economies to a great extent. The use of large-scale facilities also creates employment. Economic added value can also be generated by the spin-offs set up around a large-scale facility.

Large-scale infrastructures can drive innovation in the commercial sector by creating a learning environment where companies can use the knowledge generated within RIs to develop new products, processes and services (drive innovation in the commercial sector). On the other hand, large-scale facilities can also act as customers for innovative products and services in the course of their development which in turn can be sold to other customers or other markets as well.

An empirical study by Vuola and Hameri (2006) reveals the innovation potential of systematic cooperation between large-scale research infrastructures and industry. While the two parties may have different expectations from the collaboration, yet from the innovation point of view they all have something to gain. Industry and new technology based firms develop and commercialize new technologies and gain access to external R & D resources and big-science gets the latest technologies and capable industrial partners at low cost. *Box VI* (drawn from this study) provides an overview of the key implications for industry as a result of collaboration with large-scale science infrastructures.

Box VI: **Implications for industry from collaboration with big-science**

Financial	• Access to multiple financial sources to support the innovation process • Access to non-cost knowledge networks • Business breakthrough and long-term supply contracts
Organizational	• Enables corporate venturing instead of spinning out radical new businesses • R & D people get access to a wider social and knowledge network • Collaboration projects may take several years, which should be taken into account
Technological	• Access to unique and neutral testing and piloting environment for the innovation
Social	• At best enables innovation to happen and speeds up the innovation process • Significant marketing, motivational and technological learning resulting from the collaboration

Benefits for society/citizens

Research activity increasingly involves international collaboration either because of the need to pool knowledge and share large-scale RIs or because of the nature of the research problems to be addressed. These problems are of a scale or complexity that goes beyond the reach of most national resources and have be addressed at a global level. Therefore large-scale RIs can have a social mission, i.e. address 'Grand Social Challenges' such as climate change, sufficient and sustainable energy supply, infectious diseases or population change.

Large-scale facilities can also contribute to various types of social innovation, i.e. various new products, services and concepts that find their way in to the public domain.

Large-scale RIs also play an important role to familiarize the general public with scientific disciplines and could contribute to a better social understanding of science through the necessary publicity activities. In this respect, it should be pointed out that while this kind of large-scale research facilities might seem that they stand too far from the daily life and needs of European citizens, they have huge impacts on the quality of their lives through the use of everyday items that are based on research undertaken in these RIs. In this context, RIs can also act as a means of making a particular scientific domain more attractive and promote its study.

Benefits resulting from hosting RIs

In general, large facilities contribute to the economic growth of regions and countries through the procurement of goods and services required for the development and functioning of such facilities. The ERIDWatch project has shown that an estimate of the total annual instrumentation procurement supported by the total annual budgets of all European RIs amounts to approximately 4 B€ and it is expected to grow. Thus, there are significant supply opportunities for industry at both existing and future RIs at a national, European and global level. The total annual budgets at European research infrastructures amount almost 8-9 B€ and almost 50% of this is spent on instrumentation. This amount has increased on average by 5.5% per year over the last 10 years.

The major proportion of the investment usually involves benefits for the local and national economy (SQW Consulting 2008). This is because contracts for developing a facility or providing a service are more frequently awarded to local and national companies instead of foreign ones for reasons of lower price, physical proximity, use of local partners for maintenance etc.

The economic activity related to the development and operation of a large-scale research facility also creates employment on a temporary or a permanent basis. Temporary employment effects have to do with the creation of jobs as result of the RIs development, while longer-term effects are related to jobs created for the personnel (research staff and scientists) and for suppliers of services and materials.

Large-scale RIs typically generate direct and indirect economic impacts, similar in nature to any large public investment. However, the research intensive nature of these facilities may also have other economic impacts, such as knowledge/technology transfer to the supplier which in combination with the supplier's success in winning a demanding contract, may assist the company to penetrate other scientific markets. The following *box* provides empirical evidence on the economic impacts created by the location of large-scale RIs in Britain.

Box VII: **Economic impacts of large-scale science facilities in the UK**

A recent study (SQW Consulting, 2008) on the impacts of large scale science facilities in the UK indicated that the major economic benefits resulting from the location of five large-scale RIs in this country arise from:

- Employment of relatively highly paid staff recruited mostly from the local area while the best part of the remaining staff comes from the rest of UK;
- The awarding of contracts to UK-based suppliers. These contracts are primarily 'low-tech' ones related to construction and installation phases of the facilities where delivery costs are likely to constitute a significant proportion of expenditure. UK firms win a far smaller proportion of 'high tech' contracts. Most high technology suppliers reported some benefits related to the location of large-scale RIs in the UK, however close proximity to the facility was rarely important.

RIs are also contributing to the development of high-technology clusters in their local areas through various channels. However, local technology-based development usually predates the establishment of RIs. In addition these facilities are generally small in relation to the scientific investment required for cluster creation and growth. As such there is only limited evidence that large-scale facilities could seed on their own the development of clusters.

There are definitely examples of large-scale facilities transferring knowledge and technologies to their suppliers. However, the interviews held in the context of the specific study did not suggest this was occurring on a substantial scale, considering the volume of contracts involved. In addition, there appears to be limited scope for the suppliers to render these advances into new products or markets. A major exception is synchrotron supplies where there are many facilities at a global level giving rise to continuing demands for related leading edge products and services.

Large-scale research facilities can also be a driver of knowledge-intensive entrepreneurship though the spin-off companies that might be established near their premises (Technopolis 2011). These spin-offs are usually commercializing knowledge generated within the facility or knowledge generated at some stage in its development phase. Knowledge produced within the facility can also be brought into the market through licensing agreements or joint ventures with existing companies.

A recent survey on RIs (European Commission – European Science Foundation, 2007) indicates that 47% of the surveyed RIs are located in one of the four largest EU countries in terms of population and research effort: Germany, France, Italy and the UK. 72% of the research infrastructures with very high construction costs (greater than 250 M€) belong to institutions of these four countries. This survey also shows that there are regional concentrations of RIs in certain scientific domains. Therefore there is potential for a more balanced distribution of RIs throughout Europe that could contribute to reversing brain drain, alleviate unemployment in regions and promote European cohesion.

The EIROforum organizations (Europe's Inter-governmental Research Organizations) in their response to the ERA Framework Consultation emphasize the need to provide broader access to European RIs to more countries especially from Central and Eastern Europe. According to EIROs this would increase competition for the resources and opportunities that these facilities provide offering the potential for increasing scientific return and innovation in Europe. In addition, it would have a positive influence on researchers' mobility and would promote integration of scientific communities across Europe especially those in convergence regions that have fewer research infrastructures. They suggest that financial support (e.g. through EU structural funds) could be provided to these countries for building-up national RIs and in consequence foster local scientific excellence. In this way they will be better able to cooperate with and finally accede to the EIROs or other EU large-scale facilities.

Benefits for users

RIs have the ability to create rich research environments and attract best researchers from different countries, regions and disciplines. They can also contribute to skills and knowledge formation either via the centralization of skills or through networked collaboration between researchers giving space to the development of multidisciplinary teams. Training of researchers and engineers is also a part of their role for building research capacity. In addition, RIs can provide businesses with a learning environment as they can generate knowledge that a company cannot produce through its own R & D facilities or acquire via its existing network (industrial users).

Empirical research suggests that the majority of users of RIs in Europe are national users (European Commission – European Science Foundation, 2007). However, about 32% of all RIs report having more than 50% foreign users, which indicates that they are open to researchers from abroad. About 70% of the surveyed research infrastructures report more than 10% users from abroad. The surveyed facilities are attracting more basic and academic researchers than industrial ones: 71% of all RIs have 0 or less than 10% industry users.

Survey work indicates that the majority of users suggest that the scientific potential of the large-scale RIs in Europe is not always fully exploited (European Commission, 2010b). Transnational access to RIs is often hampered or difficult, since access to RIs is determined on a national basis (linked to national preference or national funding). Moreover, transnational access remains very costly both for the hosting facility and the researchers willing to use the latter. FP6 contracts have provided transnational access to RIs to more than 26,000 researchers. Approximately half of them were young researchers, i.e. FP6 contracts have provided high-quality training forming an invaluable human capital resource for current and future research needs. On the other hand, the number of RIs has more than doubled in FP7 compared to FP6 the number of users per year remains stable (around 6,000). This probably indicates that the current level of funding for trans-national access is inadequate for the exploitation of RIs by European researchers (Fotakis, 2010).

There are RIs of critical importance to European competitiveness with a relatively small number of users (e.g. aeronautics). However, in such cases the quality of knowledge and the added value are high. Data on access to FP6 RI projects indicate that less than 1% of the users are coming from industry.

A research among 598 European RIs indicates that most users are using the facilities on-site: about 60% of all RIs report 0 or less than 10% of remote users. By providing remote access (via electronic links) to researchers located in countries with facilities of less high quality will give them the opportunity to carry out high-quality research from their countries.

Research infrastructures are becoming increasingly diverse and distributed over various sites and are increasingly interconnected and supported by e-infrastructures. Computer storage and capacity doubles every 18 months and in general this rate tends to increase. This is a serious challenge for Europe's e-infrastructure. The important benefits resulting from the use of e-infrastructures by different types of users are summarized in *Box VIII*.

Box VIII: **Who benefits from science e-infrastructure?**

Researchers

* Have all data and tools easily available, increasing productivity
* Cross-fertilization of ideas and disciplines produce novel solutions and promote understanding of complex products
* "Stand on the shoulders of giants'

Industry

* Use the best available information for R & D, increasing productivity
* Create new knowledge, markets and job opportunities
* Provide a strong industrial and economic base for European prosperity
* Increase opportunities for mobility and knowledge exchange between industry and academia amplifying impact of innovation

Citizens

* Appreciate the results and benefits arising from research and feel more confident in how their tax money is spent
* Find their own answers to important questions, based on real evidence
* Pass on knowledge and experience to others, and make a contribution to the knowledge society beyond their immediate circle and life-spans

Policy makers and funding bodies

* Make evidence-based decisions
* Eliminate unnecessary duplication of work
* Get greater return on investment

Source: European Commission, 2010a

In sum, the empirical evidence presented above shows that the majority of users of RIs are national users, however, RIs are open to a certain extent to foreign users as well. The scientific potential of RIs is not fully exploited as transnational access is hindered by several difficulties mainly related to the level of funding. Industrial users of facilities as well as remote users are limited while (open) access to RIs through e-infrastructures is still hampered.

RIs as magnets for best researchers

Although there are no studies that have explicitly examined the attractiveness of large scale RIs to the best researchers, it is generally asserted that high-quality RIs can be one of the determining factors of researcher mobility (OECD, 2008). The best and most talented researchers wish to locate themselves close to facilities that are pivotal for building their career and reputation. To attract talented researchers, RIs must be international and develop both the highest level of scientific-technological competence and adequate management capabilities (European Commission, 2009). If a country/Europe fails to invest in adequate RIs, this may lead to 'brain drain'.

Allowing more top researchers to access RIs on the basis of excellence would increase the cost-efficiency and cost-effectiveness of operating these RIs (European Commission, 2011).

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The European Research Area (ERA) is a unified research area open to the world based on the Internal Market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States willl strengthen their scientific and technological bases, as well as their competitiveness and their capacity to collectively address grand challenges.

This report confirms that the European Research Area (ERA) increases efficiency in carrying out research activities and contributes to smart, sustainable and inclusive growth. It induces a better balance between competition and cooperation, essential for research quality and creativity. It calls for truly European framework conditions and common standards. It requires the optimal articulation and coordination of the various policy levels: regional, national, cross-border, and European.

The report was produced by the High Level Panel on the Socio-Economic Benefits of ERA, set up at the request of the Commissioner for Research, Innovation and Science, Ms Máire Geoghegan-Quinn to support the preparation of the ERA Communication. The *panel was* chaired by Achilleas Mitsos, former Director General of DG Research, with Andrea Bonaccorsi and Yannis Caloghirou acting as rapporteurs and Jutta Allmendinger, Luke Georghiou, Marco Mancini and Frédérique Sachwald as members. It was established by DG RTD in connection with the *High Level Economic Policy Expert Group on "Innovation for Growth (i4g)"*.

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