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Challenging Europe's Research: Rationales for the European Research Area (ERA)

Report of the ERA Expert Group

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This is the Final Report of one of the seven Expert Groups set up by DG Research of the European Commission in the context of the follow-up to the Green Paper "The European Research Area: New Perspectives" adopted by the Commission on 04 April 2007.

Expert Groups were set up for each of the six ERA dimensions identified in the Green Paper, and one on the overall vision and rationales for ERA.

The list of Expert Groups is as follows:

EG 1: Realising a single labour market for researchers
EG 2: Developing world-class research infrastructures
EG 3: Strengthening research institutions
EG 4: Sharing knowledge
EG 5: Optimising research programmes and priorities
EG 6: Opening to the world: international cooperation in S&T
EG 7: Rationales for ERA

The overall objective of each of the Expert Groups EG 1 to EG 6 was to identify and define possible measures and actions concerning the relevant ERA dimension, taking into account existing expertise, available evidence and the major elements stemming from the debate launched by the Green Paper. Expert group EG 7 was tasked with developing and expanding rationales for ERA and refining or suggesting a reformulation of the ERA vision proposed in the Green Paper, based on an analysis of the main issues and factors affecting the efficiency, effectiveness and attractiveness of the European research system.

More information on the ERA Green Paper debate, public consultation and follow-up can be found at: http://ec.europa.eu/research/era

Executive Summary

This report presents a rationale for a **European Research Area** that has a **clear purpose** which is **meaningful to Europe's citizens and political leaders** and **relevant to its key actors**. While there is a pressing need to improve the effectiveness of the public research system, the ultimate justification of the resources and commitment needed to achieve this lies in increasing the value of the contribution that public and private sector research makes, and is seen to make, to Europe's economic, social and environmental goals.

The central means to achieve this is to engage the research system in **Europe's response to a series of Grand Challenges** which depend upon research but which also involve actions to ensure innovation and the development of markets and/or public service environments. Challenges may be rooted in economic, social or scientific goals but share a need to demonstrate their relevance at the European level, their feasibility in terms of Europe's capability to engage with them, and a clear research dimension such that they gain the commitment of the research community and pull-through the necessary improvements in its efficiency and effectiveness.

A **research-friendly ecology** is needed to allow actors and institutions to work together in productive networks. Sub-criticality in Europe at the level of research institutions inhibits their ability to configure themselves to address interdisciplinary problems and opportunities and to work well with business. A new approach to networked specialisation is needed to address this. This links to an approach to cohesion which is based upon research institutions being supported to engage more fully with their regional context and local users.

The actors in ERA form the main locus of action and this report identifies key needs for each sector including:

- Promotion of **transnational peer review** for research funding;
- Support for the move towards greater **strategic space and autonomy for universities**;
- Active steps to develop a true **European market for applied research services** in the RTO sector;
- Continuation of moves towards a more **innovation-friendly market** for business and the conditions whereby innovation creates value in ways that benefit Europe;
- A focus on elimination of barriers to cross-sectoral mobility for researchers.

A step change in the quality of dialogue and linkages between supply and demand for research forms our third major theme, the need to re-orientate strategic and applied research in Europe in close support of the full range of policies that Member States have agreed should be articulated at European level. This involves the Framework Programme and national programmes, linked through ERA-NETs and other instruments engaging much more effectively with policy needs in areas such as the environment, transport, energy, agriculture and health. Gaining full impact from these recommendations will require that consideration be given to the effective allocation of responsibilities and procedures within Commission Services and Member States.

None of our recommendations work against the measures proposed in the Green Paper. Current efforts to address evident deficiencies in the research system should proceed and be strengthened. The focus here is on the additional needs and measures required in order to make **the compelling case for a real shift of resources** in the forthcoming budgetary round, equipping the research community to make its central contribution to the future economic and social well-being of Europe's citizens.

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1. A rationale for ERA

The vision of the European Research Area presented in this report is founded upon the principle that the core objective should be to maximise the value contributed by research, today and into the future, to Europe's economic, social and environmental goals. The research system cannot be treated in isolation from its critical linkages with innovation, education and the wider thrust of EU policies and aspirations.

In simple terms a rationale means the reasons for doing something and this report is about the reasons for having an ERA. We welcome the thrust of the proposals set out in the Green Paper and elaborated by our fellow expert groups but believe that the proposed measures do not yet go far enough. It is a valid and important objective to seek to remedy perceived deficiencies in the public research system but we need to extend the focus: first to encompass the entire research system, including business, research and technology organisations and the wider range of stakeholders who fund, support, work in or use research; and second to move beyond this from deficit to opportunity by introducing a strong content dimension to ERA.

There is an opportunity on the horizon to make a reality of the knowledge economy at a political level by securing a real shift of resources in the forthcoming round of budget reform and new financial framework. Despite the impetus given by the Lisbon objectives, we believe that the case for further investment and high-level attention to research and innovation needs to be supported by a clearer public appreciation that research, and the skills that research sustains, are critical elements in addressing the economic, social and environmental problems facing the EU. For this reason our central recommendation is that ERA should be constructed as an essential element of Europe's response to a series of Grand Challenges.

In the tradition of the EU's history of response to such challenges, we propose that ERA is rolled out through a series of coordinated actions encompassing research, but also innovation and the development of lead markets and/or regulatory and public service environments. These would seek to capture political and public imagination, create widespread interest through scientific and business communities and NGOs and inspire younger people. Within these the Framework Programme could be a catalyst and the European Parliament an important complement, but the prime impetus must come from Member States and partners in business and societal groups.

Beyond the Grand Challenges we believe that there is scope for a further reorientation of European research in close support of the full range of policies that Member States have agreed should be articulated at the European level. It is important to be clear that this is not an argument that all research at European level should be applied in nature. The promotion of excellence, including through the European Research Council, and capacity building through mobility and infrastructure support are essential parts of the research system and their support should be a high priority. However, our argument is that the Framework Programme, seen as a whole, and the work of related national programmes through ERA-NETs and other instruments can be strengthened substantially through far better alignment with support for policy in such areas as the environment, transport, energy, agriculture and health.

Achieving these ambitious goals requires a research system fit for purpose and supported by measures to make it more effective throughout Europe. We summarise these as the development of a research-friendly ecology. Within this concept we build the ERA rationale.

In the first part of this report we review some key trends which provide the context for ERA. The concept of fragmentation is identified as the core argument of the present ERA rationale. We seek to deconstruct this into its key components. At a micro-scale we explore the meaning of sub-criticality in research both at the level of the research group and at the level of institutions. We also relate this to the demand-side. The concepts of networked specialisation and regional concentration are presented as a counter to sub-criticality.

The core systemic feature of the European research landscape is the balance between cooperation and competition. In achieving this balance a key conclusion is that the trade-off is field specific and that there is no one-size-fits-all approach.

With the foundation of these analyses we are able to present the unifying concept of the research-friendly ecology. This analysis is used to supplement the insights of the research and innovation systems approach with a focus on the distribution and abundance of research performers (institutional as well as individual) and knowledge and their interactions with each other and the broad environment. This goes beyond the market analogy which is inadequate to describe the complexity of what is in reality an overlapping set of diverse ecologies.

We distinguish between rationales for working at national/regional, European and global levels and note that these are quite different for basic and applied research. Cross-border funding is much more likely to take place on a significant scale in the latter case, where the motive to buy research (to procure answers to specific research questions) strongly outweighs the spillover arguments that underpin national support for basic research. By spillovers we mean here the desire for the positive side-effects that accompany these activities, for example producing a technically trained workforce and contribution to general education.

The concept of the research-friendly ecology is best understood through the needs of its key actors and we explore the roles for research funding organisations in driving up quality; universities as key brokers between research and education; business in terms of how to achieve engagement in ERA; Research and Technology Organisations as players in a new European market for applied research; mobility of researchers as an instrument of knowledge transfer, especially across sectors; and citizens in terms of engagement. We examine the issues of cohesion and equity as they relate to ERA in the same spirit and argue that a localised articulation between supply and demand for research is needed in less-developed regions as a prerequisite for taking advantage of the benefits of knowledge flows and networking that ERA can bring.

Against this backdrop we are then ready to explore the interaction of supply and demand that is involved in implementing the Grand Challenges and bringing research and its policy users closer together. The path we propose does not imply in any way a negation of the actions taken to date under the ERA banner. Most of what we propose exists as a concept, or pilot action, or policy option. Much is implicit in the Green Paper and more is part of policies that the Commission has chosen to see as separate initiatives in the domain of innovation. What has been lacking is the drive, direction and imagination among Europe's political actors to take forward these concepts on a scale that will truly make a difference to the fortunes of its economies and the lives of its citizens.

2. ERA's achievements and assumptions

2.1. A changing environment for ERA

The world has changed since 2000. Major trends are affecting Europe in general and the research system in particular – the implications of globalisation and migration; changing social values and their interactions with science; demographic change; climate, resource and energy challenges; security concerns; and the rise of the service economy. Each of these, and their interactions with each other, create challenges both for the practice of research and for the agenda with which it needs to engage.

The immediate environment for research has also changed since 2000. Firms which were already experienced in outsourcing production today also outsource a significant part of their research and are often dependent on others for the success of their own innovation activities. One manifestation of these changes has been the rise of the "open innovation" concept. The idea that firms should source the knowledge needed for innovation from wherever it can best be supplied fits very comfortably with the objectives of ERA. Open innovation can only function when there is an ecology of large and small firms well-networked with each other and with universities, public labs and RTOs. This is not in conflict with the idea of in-house R&D – recognition and absorption of knowledge depends upon it – but it does challenge the idea that more expenditure on research is sufficient. A well functioning ecology should allow increased levels of innovation with reduced unit R&D costs and hence make Europe more competitive. Of course the increased value of R&D in this environment may in turn lead to pressure for more investment as well as steps to improve the effectiveness of the R&D, because of competition. The model is complex but the message is clear – policy must align much more clearly with natural incentives which are driving this trend.

Similar arguments apply to the use of knowledge in support of public policy and decision-making. More broadly, in this report we shall consider how a broader engagement of Europe's citizens as stakeholders and supporters of research might be achieved. The challenge is to capture the public imagination less with the process of research than with what it can achieve. There is a pressing need for a vision to achieve the necessary societal and political support.

2.2. The starting point

It is beyond the scope of this report to evaluate the achievements of the first ERA initiative. However, few would dispute that the result has been a mixture of successes and areas of underachievement. We could note for example Kuhlmann's scorecard (Box 2.1) which he summarises as "ambitious targets largely unmet". [1]

1 PRIME NoE ERA Dynamics - New configurations of knowledge, institutions and policy in Europe?, Stefan Kuhlmann, University of Twente, Discussion with European Commission, DG Research, Brussels, 13 February 2007.

On the other hand we may see positive appraisals of two of the key instruments:

BOX 2.1: KUHLMANN'S SCORECARD ON ACHIEVEMENT TO DATE OF ERA AMBITIONS

- Private research investment to become more dynamic
  ➔ Not achieved
- Effective tools to be developed to protect intellectual property
  ➔ Not achieved
- Obstacles to the mobility of researchers to be removed, and a European dimension introduced into scientific careers
  ➔ Not achieved
- A greater place for women in research to be achieved, and the young to be attracted into research and careers in science
  ➔ To a limited extent
- Europe to offer attractive prospects to the best brains, so that high quality research talent would be retained and attracted
  ➔ To a limited extent
- European S&T centres of excellence to be networked, and virtual ones created
  ➔ To a limited extent
- Regions to play a more important role in the European research effort
  ➔ To a limited extent
- Scientific communities of Western and Eastern Europe to be better integrated
  ➔ To a very limited extent

On ERA-NETs the review stated that they:

> *"…fulfilled a real need within the policy armoury of the EU in that it helped overcome barriers to the coordination of national and regional research activities, a vital step in the creation of a real European Research Area. …, the overwhelming response to the scheme (over 2,000 programme owners and participants …), suggests the release of pent-up demand amongst the research policy community."*[2]

While the Open Method of Coordination as applied to research policy was similarly endorsed by the Lisbon Group:

> *"The OMC can be regarded as a social innovation that has the potential to contribute to the implementation of the Lisbon Strategy. OMC is a very useful process to stimulate policy learning. OMC peer-review can be used as a major driving force for reforms."*[3]

There are many statistics which emphasise the distribution of research capability on Europe but for simplicity's sake we shall cite only one recent example, the results of the European Research Council's Starting Grants Competition shown in Figure 2.1.

This figure, already familiar to many, supports several conclusions, subject to the important caveat that on a relatively small population of successful applicants some of the numbers may vary widely between successive competitions. Nonetheless we can safely conclude the following:

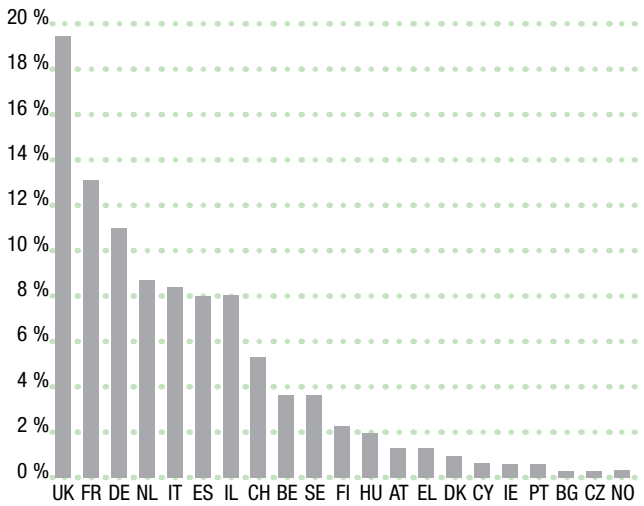
2 Horvat et al, ERA-NET Review 2006, The Report of the Expert Review Group, European Commission.
3 Lisbon Expert Group, 2006 : Research and Innovation in the National Reform Programmes. Opportunities for policy learning and co-operation.

FIGURE 2.1

Distribution of ERC Starter Grants

Country of host institution

Percentage of grants by country of host institutions



Source: ERC MEMO/07/586 Brussels, 14 December 2007

- Scientific activity is concentrated, with five Member states accounting for over half of hosting of fellows[4];
- Nonetheless, adjusting for population, several small countries do better than large ones in terms of grants per capita;
- The UK's leading position (with only half of its 19% of fellows being UK nationals) and the strong showing of the Netherlands probably reflect not only scientific strength but flexible research systems and the English language, each making it easier for researchers to locate themselves there.

The ERA concept is set against this backdrop of a quality gradient, a distributed research system and the recognition that the conditions for research can influence significantly its location and impact. The next task is to explore how this setting is taken into account as the set of policies under the ERA label.

2.3. The meaning of fragmentation

The original 2000 vision of the European Research Area[5] was founded upon a number of propositions and diagnoses. The context was an unfavourable gap analysis on a series of research and technology indicators with the US and Japan. This analysis was linked to economic performance in a way that was inevitably conditioned by a view of the knowledge society as seen from the perspective of the late 1990s technology boom. A key paragraph summarises the diagnosis and rationale for addressing the research system in Europe:

> *"Above the European research effort as it stands today is no more than the simple addition of the efforts of the 15 Member States and the Union. This fragmentation, isolation and compartmentalisation of national research efforts and systems and the disparity of regulatory and administrative systems only serve to compound the impact of lower global investment in knowledge."*[5bis]

Other barriers are also cited, notably those between disciplines and between academe and industry. A lack of a European policy on research is expected to become worse with enlargement. This is linked to the concept of developing a European market of supply and demand in knowledge and technology.

The present Green Paper[6] retains much of the original analytical structure: The perceived main rivals are now China, India and emerging economies; and the European internal market for research and coordination remain prominent. The key image of fragmentation remains central, with the Green Paper stating:

> *"…much ground work needs to be done to build ERA, particularly to overcome the fragmentation which remains a prevailing characteristic of the European public research base. Fragmentation prevents Europe from fulfilling its research and innovation potential, at a huge cost to Europeans as taxpayers, consumers and citizens."*[6bis]

4 And in reality a small number of regions and institutions within those Member States.

5 Commission of the European Communities, Towards a European Research Area, Brussels, 18 January 2000 COM (2000) 6.

5bis Idem note 5, page 7.

6 European Commission Inventing Our Future Together – The European Research Area - New Perspectives, Green Paper 04.04.2007 DG Research, COM (2007) 161, EUR 22840.

6bis Idem note 6, page 7.

In exploring the rationale for ERA, it is essential to understand what is meant by fragmentation and why this should be seen as damaging.[7] The basis for the fragmentation argument must rest in the fact that the overwhelming majority of public research in Europe is financed and governed through 27 national systems (and regional ones below) which, as we have seen, vary considerably in scale and overall quality. However, this observation does not in itself constitute fragmentation. There must be systemic characteristics and consequences arising from this multi-centred and multi-level governance of research. The Green Paper emphasises five negative consequences of "fragmentation":

1. Barriers to researcher mobility inhibiting career opportunities;

2. Difficulty in establishing cross-border academic industrial partnerships;

3. Duplication of funding between national/regional programmes dispersing resources, losing spillovers and making Europe's global role sub-critical;

4. Lack of European perspective and transnational coherence in reforms undertaken at national level;

5. Diminished attractiveness as a location for business R&D investment.

All of these, if proven to exist, are **system-level failures** involving inadequate selection mechanisms and incentives to improve efficiency, effectiveness and learning capability. Such failings are at the level of **governance** of research, implying a lack of coordination and/or cooperation among research support institutions. Such institutions include the funding bodies but also all other levels at which resourcing, regulatory or structuring decisions are taken which affect research. It could also extend to the framework conditions in which research operates – general market and labour conditions are probably somewhat more affected by national differences. As a first step we consider what might be the inverse of fragmentation with reference to the case of the USA (see Box 2.2). This shows that the kind of comparisons upon which ERA arguments rest are somewhat more complicated than are first apparent. We shall explore the rationale for diagnosing systemic failings in a later section but first we need to consider whether fragmentation exists on the micro-scale.

7 Fragmentation in its literal sense is an inappropriate metaphor – the word describes a situation where something that is whole has been broken or divided into pieces while for Europe the aim is the reverse.

BOX 2.2: COMPARISON WITH THE USA CAN BE MISLEADING

Virtually every high level European policy document in the realm of productivity, innovation or research rests its arguments in part upon comparisons with the USA. The ERA Green Paper is no exception. In many ways, the existence of a single country of a similar scale to Europe is seen as the inverse of fragmentation. It is useful to consider what such a unitary system can or cannot offer.

The presumption is that the USA is able to minimise or avoid the negative consequences of fragmentation. Such an analysis would assume that the USA can focus its resources; avoid unnecessary duplication; operate an unhindered national labour market in research; and provide an attractive environment for business R&D; and that academic-industrial partnerships occur unhindered between firms and institutions irrespective of their geographic situation because of the common legal framework at national level. These points are deliberately not ordered here so that the reader can observe that they vary considerably in their degree of accuracy, and also that factors other than research may be critical.

For example, the USA prides itself on the plurality of its funding sources for research arguing that a greater variety of projects may be selected and competition between researchers stimulated, albeit at a greater cost. However, this multiplicity is not generally one of redundancy at the level of governance as funding comes mainly from the existence at national level of mission-oriented agencies in defence and security, health, energy etc but which nonetheless recognise the need for funding challenging research. The very high funding levels especially in health, defence and security should also be noted. To the interested observer it appears that any problems of duplication that this approach creates are more than outweighed by the ability of individual project officers to re-direct resources towards more successful approaches, in other words an inherent agility. At the level of execution there is a greater diversity of types of higher education institution and a higher level of circulation among them.

The attractiveness of the USA as a location for business R&D is certainly related, at least in part, to the high quality of its research base. It is even more strongly driven by the large and innovation friendly market that it offers. Other differences, such as the efficiency of regulatory processes, also play a part. There is no compelling evidence that formal industry-university links work better in the USA than in Europe. The difference lies more in the opportunities that their alumni exercise in the entrepreneurial establishment and, especially, the growth of new technology-based firms. The conclusion is that while the US research and innovation system has many strong points from which lessons may be drawn they require careful contextualisation and may not correspond to the received wisdom.

Such an argument would rest on an analysis that many elements of the system are **sub-critical** and may achieve higher potential through combining those policies, institutions, resources or research teams that have always been distinct entities. Unlike the governance level of systemic failings, the problem here is seen at the level of **execution** of research, manifest among research performers and the organisational settings in which they work. The argument runs on the basis that, while Europe has a large number of researchers, they are working in sub-critical units and their effort and the resources they require cannot be concentrated sufficiently for them to reach a world-leading position. By looking at the micro-scale, we seek to understand whether sub-criticality can offer an explanation for apparently poor relative performance at world level of individual fields, institutions or groups of researchers.

In the rest of this section we elaborate these concepts and locate them in a framework of policy for research. In Section 3 we then move on to the main elements of our proposed approach.

8 In some countries this may be termed a "lab" but this term risks confusion with whole institutions. The definition of a research group here is a team of scientists working on a single problem set, normally within a single institution, and characterised by one or more leading scientists, other qualified scientists working under their direction, post-doctoral researchers, graduate students and technicians.

2.4. Sub-criticality

Beginning then with micro-scale fragmentation, to be sub-critical means that the effort in a particular field or sub-field lacks resources, equipment or a sufficient number of researchers to achieve a desired goal. The inverse is "critical mass", an analogy that implies that there is a threshold size as which working becomes effective. At the level of a research group, which we shall assume is the normal working unit of science,[8] sub-criticality may be manifested by an inability to afford the equipment necessary to be at the leading edge of a subject – say for example the highest resolution NMR machine; or to establish or access enabling structures which develop to the required standard, such as support for bioinformatics. The problem may be too few researchers of sufficient quality to progress the work. In such cases the most likely cause is insufficient resources. A second cause may be an actual shortage of suitably qualified researchers available for hire. Equally, there may be insufficient demand from the local research constituency to justify the development. The situation can be self-reinforcing in that quality researchers are attracted to groups with established reputations, which then develop the infrastructures to support the work of their own research community and the work of a broader, often global, constituency[9].

The existence of sub-criticality has been explored in several studies. A comprehensive review on the topic carried out in 1994 for the Australian National Board of Employment, Education and Training reached three conclusions:

1. *"There is a positive critical mass, or threshold effect, in many fields of research in the natural sciences. Below a certain size, variously estimated at from 3-5 academic researchers plus post-doctoral fellows, post-graduate students and technical staff, research performance is reduced. In general, if research groups grow significantly larger than this size, inefficiencies set in which lead to fission. This size represents the mode of research groups. There are, however, exceptions with strong research performance from groups of smaller size, and occasionally individuals.*
2. *There are no economies of scale, beyond this threshold effect. In general, productivity increases only linearly with size.*
3. *Large, well-funded and well-led research groups produce more publications, of higher impact, and receive much higher international recognition than do smaller groups, when group output is the basis of comparison."*[10]

A more recent review for the UK Government confirmed the main finding of the size of the optimum team in terms of scientific productivity being no more than 5-9 persons (for both studies this number excludes associated post-docs and postgraduates).[11] However, the review extended the argument to state that for the meso-level of departments and the macro-level of whole institutions, productivity was simply a multiple of sub-units of 8-9 persons and hence linear once this threshold was crossed. Both studies recognise the severe methodological difficulties involved in defining productivity in science. Most of the literature covered relies on bibliometric indicators – there is no consideration of socio-economic productivity through third mission activities, a point to which we shall return.

Focusing particularly on Europe, a recent study on universities and strategic knowledge creation examined whether there were economies of scale in the production activity of universities using a sample of 271 universities from 5 countries.[12] Using their non parametric approach, the authors consider economies of scale. For research the results show decreasing returns to increasing size up to around 3000 staff and then a sharp increase in productivity up to 8000. Current results show a decrease again beyond that point but this result is linked to a small number of very large continental universities. The inference is that a 'generalist' university covering the four main fields is needed to achieve the positive returns. For teaching there is a positive effect of size up to an academic staff of 3000 and then a linear relationship.

Looking at scale in a different way, bibliometric work tends to suggest that Europe achieves "peaks" or "islands"

9 The Cambridge Crystallographic Data Centre is a case in point.

10 Johnston R, Effects of resource concentration on research performance, Higher Education 28: 25-37, 1994.

11 von Tunzelmann N, Ranga M, Martin B and Geuna A, The Effects of Size on Research Performance: A SPRU Review, June 2003, http://www.sussex.ac.uk/spru/documents/geunaost.pdf.

12 Bonaccorsi A and Dairaio C (eds) Universities and Strategic Knowledge Creation – Specialisation and Performance in Europe, PRIME Series on European Research Policy, Edward Elgar, 2007.

of excellence, in that relatively small research units such as certain Max Planck Institutes or the Molecular Biology Laboratory may be world-leading in terms of average citation performance but that large US universities sustain performance at these levels across a far wider range of publications and fields[13].

Taken together, these items of evidence suggest that sub-criticality may be a more significant factor at the level of the institution than it is at the level of the research group. The reasons for this in part arise from economies of scope. Though more research is needed on this issue we can make a series of observations:

1. The growing multi- and inter-disciplinary nature of research means that a field is more likely to advance if complementary and neighbouring disciplines are also strong in the same institutions or similar close proximity. Economies of scale may also be present when groups and even disciplines can choose to share expensive equipment such as microscopes and other analytical instruments;

2. When it comes to the problem-based interdisciplinary research which is often of most interest to industry and other users, the ability to configure teams from a wider range of capabilities is an advantage, reducing the transaction costs for the collaborating firm;

3. On a similar basis there is a tendency for larger firms to conclude framework agreements with a selected small group of universities, hence reducing the administrative overhead for both sides. Such agreements may cover standard payment and intellectual property arrangements and can extend from research, through executive education and even to training and recruitment of graduates;

4. More diversified institutions are better able to cope with shifts in funding patterns from one field to another which may result from changes in which areas of research are considered most promising for investment.

13 PREST/Evidence Ltd study for UK Office of Science and Technology.

BOX 2.3: R&D SUB-CRITICALITY AND PHARMACEUTICALS AND BIOTECHNOLOGY-RELATED HEALTHCARE

The fields of pharmaceuticals and biotechnology-related healthcare illustrate well the issues of sub-criticality in research discussed in this report, and reveal the dependence of sub-criticality on demand side and regulatory factors that fall outside the scope of research policy. They highlight the importance of proximity, the interplay between competition and partnership as driving forces, and the specificity of approach in particular fields.

Worldwide, pharmaceuticals and biotechnology firms currently invest more in R&D than firms in any other sector (over €70 billion in 2006), and show the highest growth rate in these investments (+15.8% in 2006)[14]. Europe has been, and remains, a strong global player, both industrially and in terms of the quality of its public research base, with many of key scientific discoveries continuing to be made in Europe. However, there has been a relative decline in relative R&D investment and in introduction of new molecular entities to market in Europe compared to the United States[15]. The emergence of fundamental new scientific understanding has not so far made drug discovery cheaper. On the contrary, many observers believe that the current escalation of costs may be unsustainable at a time when the promise of new treatments seems high.

Investment and R&D activity are highly concentrated in a few very large firms, but also involve many, very dynamic small firms. There is closer clustering and more need for proximity with university science departments than in fields such as ICT, where clustering with customers and with suppliers are more common[16]. The concept of the research pipeline is fundamental to current business models: the larger firms contract out specialist work to many small firms; new methods come into large-scale use as a result of the entrepreneurial efforts of university spinouts and their subsequent acquisition; and there is considerable dynamism in the sector as large companies traditionally operating in quite different sectors (e.g. software services and consumer goods) start to address the opportunities presented, for example, by the emergence of systems biology and digital medicine.

Healthcare is a field where the consequences of large R&D investment, complex testing and approval processes, and the willingness and ability of purchasers to pay for advanced, expensive new treatments reinforce one other to produce the observed trends.

Only those few universities with world-class research really have a chance of being regional growth engines. However, these universities do not, and cannot, carry out clinical trials and other safety tests, nor are they responsible for regulatory approval or treatment decisions.

Nonetheless, sophisticated advice and expertise is required to design effective trials. These skills are in short supply in any particular country by comparison to the United States[17] and the situation is exacerbated by competition between European member states and consequent differences in approach.

From the perspective of industrial development, the important part that played by small companies in this process and the perceived superiority (simplicity and effectiveness) of support mechanisms available to smaller companies in the United States compared to Europe serve to reinforce one another. Similarly, the purchasing decision model in the USA (more closely linked to the patient) makes the development of some new treatments more interesting there. The consequences of these points are then reflected in the investment decisions of the large companies whose activities serve to hold the whole system together and which require proximity and economically-attractive markets.

The positive feedback that results serves to reinforce issues of R&D sub-criticality in Europe. No individual player can resolve these issues independently of the rest. This has been a large part of the justification for the partnership model of the Innovative Medicines Initiative JTI, and why lead market thinking is considered so important for Europe's competitive future when social provision of healthcare remains seen as the preferred model.

14 Monitoring Industrial Research: The 2007 EU Industrial R&D Scoreboard (IPTS, 2007).

15 In 1990, European pharmaceutical industry invested €7 billion in its R&D and US industry invested €5.5 billion. By 2004, the situation had been reversed, European firms investing €21 billion, US firms €27 billion. During this period, the leading location for the introduction of new molecular entities to market also switched (1990-94, 88 in Europe, 49 in the US; 2000-2004, 57 in Europe, 70 in the US) (Constant 2003 exchange rates, source EFPIA, 2006).

16 Growth Cultures: The Global Bioeconomy and its Bioregions (Cooke, 2007).

17 Note that this remark applies primarily to the trials process. Good progress has been made on streamlining the regulatory approval process among European countries.

Point 1 above is concerned with the ability of an institution to perform good science – essentially a rationale endogenous to science. Points 2 and 3 address directly the ability of institutions to obtain an economic or social impact from their research – an exogenous rationale, although of course doing good science is also a pre-requisite for achieving external impact. Finally, point 4 may apply in either circumstance, depending on whether funding shifts result from public policy or market pressures.

The importance of the institutional level also serves to make the point that improving the efficiency and effectiveness of research institutions (universities and public research organisations) should be a key ERA objective.

Sub-criticality may also be related to the demand-side – in Box 2.3 we show how the success (and location) of the pharmaceutical and related-sectors can be affected by the inability to configure sufficient expertise to conduct effective trials. It is clear that a different but nonetheless very important kind of fragmentation exists in the regulatory and market environment that Europe offers.

What is the role of ERA in such an environment? It becomes clear that sub-criticality should be addressed in two main ways, the first of which compensates for sub-criticality and the second of which seeks to eliminate it:

1. Networked Specialisation: by exploring ways in which networking and closer association between research groups can compensate for an inability to provide all of the components needed to take advantage of the synergies described above.

2. Localised Concentration: by strongly encouraging a process of agglomeration at institutional level. This is an action which may be taken forward at multiple levels, national, regional and by the institutions themselves.

Networked specialisation

Networked specialisation implies a shift in collaboration policy – for example, a primary goal for Networks of Excellence has been to bring together *similar* groups. A wider concept is needed to explore complementarity. Such complementarity already drives most collaborative research projects but the transaction costs involved in the constant cycle of application and reassembly of teams mitigate severely the benefits of flexibility and of competitive allocation. A new trade-off needs to be found, particularly if public or industrial policy intends to address quite long-term, mission-oriented projects based on partnerships. As we set out in Box 2.4, the leading edge literature on specialisation argues that knowledge spillovers are maximised when "related variety" exists – meaning neither too much specialisation nor too much diversification. In simple terms you need to absorb knowledge from neighbouring sectors as well as from your own.

Initially the policy aim could be to gain more value from existing specialisations but the question would then arise as to whether in the longer run the aim should be to reinforce these. This more proactive view of specialisation is a concept envisaged under ERA. It is a direction imagined as a policy outcome which to some extent occurs naturally, either through favourable external circumstances or simply through a tradition building up founded on initial excellence. If the complementary research capabilities are in another country then a key condition of an institution, or even a nation accepting policy-driven specialisation, would be an assurance that the research will produce available benefits beyond the immediate environment of the research performing institution (in effect cross-border spillovers). For national policymakers to accept specialisation elsewhere in something their own researchers depend upon there would need to be some quid pro quo in terms of a corresponding inward flow in another field where the country considers that it has a stronger base.

It should be made absolutely clear that we are **not** advocating some kind of Olympian view that allocates specialisations in Soviet style to particular regions or institutions. Rather we are saying that specialisation could be encouraged to evolve by competitive means by creating larger and longer-lived agglomerations of research funding – effectively centres of excellence. These would then act as a core around which both further funding and networks could be clustered.

In practice this is likely to be a fluid picture where the conditions favouring the existence of particular centres of excellence ebbs and flows over a period of a decade or two. Successful specialised centres may or may not also become the hubs of networks of smaller units or even individuals working in that field and keeping up through regular visits, training and other forms of contact.

BOX 2.4: SPECIALISATION AND RELATED VARIETY

The traditional view from economics, normally called Marshall-Arrow-Romer (MAR) takes the view that specialisation drives innovation and growth best, by which they mean sectoral specialisation. Jane Jacobs (Economy of Cities) argues the opposite, namely that variety or diversification is best for both: that cities have diversity thus tend to grow fastest (ceteris paribus).[18] Glaeser et al disagree, saying Growth in Cities is due to specialisation (notably in human capital).[19]

A proposed solution to this binary debate has come from evolutionary economic geographers. This is that neither specialisation nor diversification is as strongly associated with growth as 'related variety'. Subsequently Cantwell & Iammarino found the same for innovation scores.[20] Related Variety means neither too much specialisation nor too much diversification. In the former case knowledge spillovers hardly arise; in the latter 'cognitive dissonance' undermines 'absorptive capacity' (of the vertical kind indicated by Cohen and Levinthal (1990).[21] Boschma [22] extends the concept of proximity to five dimensions (cognitive, organizational, social, institutional and geographical) and explores the balance between coordination and lock-in through too little or too much proximity respectively.

The key points about related variety are that:

a) There is a proximity effect rather than a portfolio effect (proximity here meaning relatedness among sectors, not necessarily geographical, though that helps)

b) Knowledge arising in one sector may rapidly be understood and adapted/applied in neighbouring sectors

c) Innovation may similarly be rapidly adapted/applied in neighbouring sectors

d) 'Lateral' absorptive capacity is thus as, if not more, important as vertical - especially in more 'open innovation' settings compared with a Cohen/Levinthal world of vertical integration/disintegration

Many top clusters, notably Silicon Valley, Baden-Wurttemberg, North-Central Italy, and Jutland/Denmark, have such RV characteristics.

To date the only area in which policy-driven specialisation is widely implemented involves **large infrastructures** which are indivisible and cannot be afforded by single countries. In most cases these are facilities which all researchers use on a temporary basis (e.g. beam sources or archives), or are staffed by international teams, and in all cases transnational governance arrangements are in place. Substantial investments are made to ensure effective global access and use of data[23]. Nonetheless it is widely recognised that scientific and economic spillovers exist for the host country.

Localised concentration

Initiatives to achieve scale through mergers of institutions are essentially a regional or national issue except in rare cases where a cross-border option exists[24]. ERA policies should seek to enhance the capability of concentrated institutions through facilitation of the inward movement of researchers from outside the regional or national labour market and hence to raise the quantity and/or quality of recruitment. This is the essence of **concentration**. It can

18 Jacobs J (1969) The Economy of Cities, John Wiley: New York.
19 Glaeser E.L, Kallal H.D, Scheinkmann J.A and Schleifer A (1992), Growth in Cities, Journal of Political Economy Vol 100 No 6 pp1126-1152.
20 Cantwell J and Iammarino S (2001) EU Regions and Multinational Corporations: Change, Stability and Strengthening of Technological Comparative Advantages, Industrial and Corporate Change, Volume 10, Number 4, pp. 1007-1037.
21 Cohen WM and Levinthal DA (1990) Absorptive Capacity: A New Perspective on Learning and Innovation, Administrative Science Quarterly, Vol. 35, 1990 pp128-152.
22 Boschma, R. A. (2005) Proximity and Innovation: A Critical Assessment. Regional Studies 39(1), 61–74.
23 For example, the IT systems needed to enable worldwide analysis of the data generated by the Large Hadron Collider.
24 The Aachen-Leuven-Eindhoven region and IMEC are cases in point.

and does take place without such intervention, in that researchers tend to gravitate towards leading centres in their field and such centres are more successful in securing the resources which enable such concentration. It is also the case that concentration may be driven by external circumstances such as a favourable regional environment including external localised linkages – a point to which we shall return later. However, the research governance of some countries is much more conducive to such accumulations than it is in others[25]. The core conditions are **competitive resources** and the freedom of an institution to hire researchers in areas it deems to be of priority, summarised in the concepts of **institutional autonomy** and **strategic space,** themes that we shall return to in the section on universities below. Concentration should be distinguished from selectivity, a focus of resources upon a particular priority area of research.

Both networked specialisation and regional concentration benefit from and foster permeability. As with open innovation, an open research system may promote permeability in other ways through more efforts being made to make codified and tacit knowledge available, the former through effective open source repositories for publications and the latter through networking and circulation. In keeping with one of the main underpinning themes of this report, the flows we describe should be both within the academic system and beyond to and from user communities, as a further means to bring into harmony supply and demand for research. From a policy perspective, there are considerations in terms of the European-wide conditions that foster knowledge transfer (access to data, IPR regimes, etc); conditions at the very local level (such as the types of professional skills and attitudes that are encouraged and developed); and at the intermediary level, such as groups' ability to locate others who can contribute to resolving the problem of interest and the qualities of the conduits between these groups.

To summarise, the key points and policy implications of our analysis of sub-criticality are:

- The threshold for a research group to achieve critical mass is generally quite low, in the range of 5-9 persons. Actions may be needed to link researchers who are isolated in units below this number but this is not the core of the problem;

- Sub-criticality is more important at the level of the research institution, particularly when it comes to confronting interdisciplinary problems. The presence of complementary and neighbouring disciplines allows both for shared resources and the ability to configure expertise around problems;

- Sub-criticality can impact upon the ability to work effectively with business, especially when combined with fragmentation in markets and the regulatory environment. Solutions need to address these issues simultaneously;

- Networked specialisation involves an active policy of linking complementary rather than similar research units. The concept of related variety tells us that a trade-off needs to be made between specialisation and diversity;

- Specialisation may also be supported through policy incentives but these should involve competition for larger and longer-term units of competitive funding rather than any planned allocation of resources;

- To provide the base for both specialised centres and the larger institutional units within which they are more likely to succeed, the relevant public authorities need to promote concentration of smaller institutions. ERA cannot cause such combinations directly but it can improve the conditions by which such institutions could attract researchers and improve their permeability to cross-border knowledge flows.

25 Examples are Tecnalia in the Basque Region, the University of Manchester in the UK and Paris Est University in France.

2.5. Cooperation, coordination and competition as the targets for redressing systemic failures

The principal systemic failures targeted by ERA concern cooperation and coordination and their partial inverse, competition. A key policy objective for ERA players is to balance these. In some sense **competition** is the base state. Competition is of course at the core of business and business-led innovation but academic researchers also compete for primacy of discovery and publication, and in so doing for resources of every kind. Until the advent of the European Research Council, rewarding excellence was often not recognised as an explicit and primary policy objective, though competitive funds were of course always present.

Excellence in science is more of a relative concept than an absolute one – consider the growing influence of university research ranking tables. At a systemic level there are also benefits in variety which might be suppressed by excessive cooperation. For small countries finding niches from which to compete is an important strategy.

However, competition like cooperation has its limits. Excessive competition for resources can be a real force for the splitting-up of effort into shorter-term projects, with high transaction costs to support their allocation (recent over-subscriptions illustrate this) and removing the ability of institutions to develop new areas and platforms. While market analogies have their limitations as we shall discuss in section 3.2, it is clear that competition in research is not a level playing field and hence that market failure concepts may be applied. For example there are barriers to entry to the funding system for early-career researchers without a track record (proven by the number of compensatory schemes offered by research funding bodies).

From an ERA perspective, though, we are more interested in systemic failures that could potentially lead to duplication through each country chasing the same targets and potentially coming up with the same priorities. In part these could arise from insufficient information about what others are doing. However, we are sceptical about whether such duplication exceeds what is necessary for competition if we increase the level of granularity. It is surely true that each country prioritises biotechnology, for example, but the precise focus of that biotechnology can often reflect the country or regions socio-economic priorities or research tradition. Hence one sees strengths in plant genomics in the Netherlands and in biotechnology relating to the dairy sector in Ireland.

Nonetheless, the broad trend in research is to compete in larger units, either in the context of semi-permanent alliances or on a project-by-project basis. In business as we saw in Section 2 this is part of the function of open innovation, while in academic research we may detect a variety of motives. **Cooperation** is so much a part of the fabric of science that it must be asked why specific measures are needed to promote it. All indicators point to a large and growing proportion of international co-authorship of publications both within and beyond Europe. Growing ease of communication (physical and electronic) and the accelerating pace of scientific progress are two of the drivers here. However, the underlying rationales for cooperation endogenous to research include:

- Access to complementary expertise in scientific teams beyond national borders, or put more broadly, gaining access to transnational knowledge networks;
- Access to, or sharing the cost of, major facilities;
- Access to unique environments (e.g. geological phenomena) or populations (for example genetic or disease profiles) or specific institutional arrangements (for example the national context of public policy);
- Achieving critical mass through cost sharing or combination of datasets;
- Addressing trans-border or global problems, for example in environmental protection;
- Fostering international mobility in science, where cooperation provides the basis for the development of scientific careers.

We have already discussed cost-sharing of facilities, and similar arguments apply to datasets except that these exist in virtual space and hence carry fewer (though not negligible) hosting benefits. For the other motives the key tests for ERA policy action are:

1. Is there insufficient cooperation for the field to progress effectively in Europe?

2. Does the desirable level of cooperation require policy support?

Successive Framework Programmes have sought to meet this rationale, usually couched as the concept of European Added-Value. For ERA the rationale is still valid but the actions on scope include all activity at European level, not just that initiated or managed by the European Commission. It would be very surprising if all fields were to benefit equally from increased levels of collaboration. The more likely situation is that some have already reached a suitable level (or may even have overreached if the additional transaction costs of cooperation are factored in) while others are deserving of more effort. If we contrast such fields as space research, chemistry and genomics, the intellectual, socio-economic and infrastructural characteristics of the fields all exhibit different patterns of specialisation and concentration and different requirements for cooperation. The conclusion is that there is no one size fits all solution for ERA development and a rationale for action needs to be made on a case-by-case basis.

It is important also to note that systemic failures may occur not because the prescription of cooperation is wrong but because the measures to promote and implement it are not well-designed or managed. This is an important area for learning and should by now be a source of European advantage.

To the list of motivations endogenous to science may be added a series of motives exogenous to research but which nonetheless closely impinge upon it and involve **coordination**. Coordination implies some form of network governance which brings together elements which are separately driven to their mutual benefit, possibly involving a division of labour. It is normally more effective if commitment comes from a bottom-up initiative in which participants themselves recognise the benefits of joint action, even though subsequent stages require effective management at the core. Joint Technology Initiatives and EUREKA Clusters are good examples of policy evolution in this direction. The link to competitiveness is one such area where cooperative networks may offer European industry a stronger basis to pursue its goals, either through more comprehensive and effective research or through the use of research to support the development of standards with market benefit.

Closely analogous is the use of research in support of other policy goals of the EU such as health and protection of the environment and understanding key societal issues such as migration and security. It is also a key element in the use of science to further the broader foreign policy goals of the EU through cooperation with Third Countries. These exogenous motives only operate effectively when research is coordinated with complementary actions, a topic returned to below.

Once again, no one-size-fits-all approach is possible but the requirement is to achieve greatest overall effectiveness. Since it is not possible to carry out at European level case-by-case assessments of the tradeoffs between competition and cooperation, the policy requirement is to achieve supportive conditions whereby the actors themselves can make and then implement these decisions for themselves.

Taking forward the main points from this discussion:

- There is a careful balance to be struck between competition and cooperation. Competition is the prime driver of research excellence but too much becomes dysfunctional because of high transaction costs and a squeeze on the ability of institutions to develop autonomous strategies;
- The degree to which research is duplicated in Europe is an empirical question deserving of further research but its apparent extent is likely to be exaggerated at high levels of aggregation;
- Cooperation is a natural and growing part of the fabric of research but there is no one-size-fits-all prescription – each sub-field at different stages of its development will have different and specific needs for cooperation and hence a rationale for ERA promotion of linkages needs to be made on a case-by-case basis;
- Coordination is understood in this report as some form of network governance and is most effective when it is founded upon bottom-up initiatives. It is a necessary initial condition for large scale mission-oriented projects even though effective management is needed once demand is articulated and that commitment is made.

3. Exploring rationales

3.1. The research-friendly ecology

We use the concept of the research-friendly ecology as our organising principle to describe the rationale for ERA. Subsequent sections focus on ways of giving ERA greater content and direction: here we concentrate more on achieving the conditions that facilitate research making a greater contribution to wider goals. Facilitation comes from seeking ways that help researchers and institutions to raise the quality of research in Europe. It also comes from improving the connectivity and communications between the actors who support, perform and use research.

We choose the term "ecology" deliberately, in preference to the more generally used concept of research and innovation system, although the starting points are similar. System approaches are concerned with interactions: the idea, for instance, that innovation concerns interactions between firms and public agencies and their external environment, involving the full range of actors affected by ERA, universities, research and technology associations, consultancies, suppliers, users, regulators, collaborating firms and even competitors. These approaches include environmental features such as corporate governance systems, tax regimes, labour market regulations, intellectual property frameworks, physical infrastructures such as energy supplies, and regional features such as clusters. They share the view that key qualities such as knowledge transfer (or sharing) arise from non-linear processes that require the marshalling of a whole range of competences which develop cumulatively over time. (The innovating organisation integrates market opportunities with research, development, design, finance, production etc in a process of continuous feedback; the effective research organisation requires effective integration of infrastructure, transdisciplinary approaches, etc.) Finally, they emphasise the critical role of education and research as a knowledge infrastructure.[26]

The added value of thinking of this system as an ecology is the focus it brings to the distribution and abundance of research performers and knowledge and their interactions with each other and the broader environment.[27] We should be clear here that research actors are frequently organisational actors. Research and knowledge production are activities developed in an organisational context. ERA policy must engage at this level and recognise that there is not always an identity of interest with the individual researcher. Some see the principal characteristic of an ecosystem as its stability. We want to move beyond this to emphasise the adaptive capability that is provided by dynamics and evolution. The goal is to achieve sustainable networks of open and mutually beneficial interactions and learning between:

- Research performers (Individual researchers, Universities, RTOs, Business);
- Research Funders (Research Councils, Sectoral Ministries, Business, NGOs, EU, International);
- Beneficiaries (Business, Government including the Commission, Society and the wider Public)

and supported by European transnational and trans-regional flows of:

- Money (Funding for research);
- Knowledge (IP and informal knowledge transfer);
- People (Researchers);
- Services (Scientific services such as metrology).

26 A fuller version of this discussion of innovation systems rationale may be found in Georghiou L, Smith K, Toivanen O and Ylä-Anttila P, Evaluation of the Finnish Innovation System, Ministry of Trade and Industry Finland, Publication 5/2003.

27 There is a growing tendency to apply the ecology analogy to knowledge (see Bowonder B and Miyake T, Technology Management: a Knowledge Ecology Perspective, Int. J. Technology Management, Vol. 19, Nos. 7/8, 2000 pp662-684); business-university linkages (Coombs R and Georghiou L, A New Industrial Ecology, Science Vol 296 19 April 2002 471); creative cities (Dvir R and Pasher E (2004) Innovation engines for knowledge cities: an innovation ecology perspective Journal of Knowledge Management Vol 8 No.5 16-27 and the environment for innovation (Wulf W, President of US National Academy of Engineering, Refreshing the Innovation Ecology, AAAS-CSPO S&T Policy Review: Highlights of the 2007 Forum on S&T Policy.

There is a tendency already to talk of a "market for research" in Europe. It is more accurate to say that we have complex systems of markets (mainly for the research required by the corporate sector, but also for scientific labour), quasi-markets (often part of attempts to commercialise RTOs), and various degrees of competitive allocation of resources for public research which nonetheless do not operate on market principles. Even where markets exist they are defined by institutional arrangements. The persistence of national, regional, and also corporate institutions and infrastructures is an important feature which results in overlapping sets of diverse research-friendly ecologies. Each in turn is linked to a wider set of ecologies which also encompass innovation. The resource inputs upon which research depends are not sustainable at anything like present levels unless these linkages remain strong.

3.2. Rationales, types of research and levels of governance

In this section, we seek to build on the conventional 'OECD style' rationales for public support for research which were largely conceived at national level, but here the aim is to understand why, or in what circumstances, research should be carried out at the European level, meaning either pan-European or sub-sets of nations and/or regions (so-called variable geometry). Since European is only one possible form of supranational organisation, we also explore the 'upper bound', summarised by the question 'why not global?'

Table 3.1 seeks to summarise the reasons for supporting research at the European level, placed in a spectrum that considers also the rationales for the national and global levels and distinguishes between basic and applied research.

At each level, there are benefits to gain and costs to overcome. When benefits already outweigh costs, the argument for change is straightforward, even though the change may not be easy to implement. Even when this argument is not yet clear-cut, other considerations (such as rates of developments in other parts of the world or emerging global scientific and technological challenges) may strengthen the rationale for change and require action to reduce the associated costs.[28]

Our discussion of the continued rationale for ERA is grounded upon the combination of current and prospective arguments, relating to the capacity of European economies to address their economic and social interests. Particularly at the current state of European development, the detailed underpinning for such arguments needs careful presentation so as to substantiate the case and mobilise wide support and resources, and avoid the risk or accusation of overstated benefits and understated costs.

28 There are already good examples of firms that have achieved substantial improvements in the effectiveness and impact of R&D carried out in Europe because of the need to be competitive in the Chinese market.

TABLE 3.1
Rationales for Levels of Governance

	Basic Research	Applied Research
National and sub-national/ regional	• Correcting market failures arising from public goods, uncertainty and spillovers and enhancing the (non-linear) benefits of basic research e.g. knowledge, trained people, equipment, problem solving	• To support other branches of public policy • To support innovation and competitiveness
Evolving, e.g., as groups of nations seek to overcome issues of sub-criticality at the level of the nation state		
Why European?	• Further enhancing collaboration and virtual common pot approaches that will stimulate competition in research and achieve economies of scale and scope (e.g. more chance to find complementary skills) • With these spillovers mostly dependent upon flows of people and knowledge (mobility), a key issue is how much these spillovers can be cross-border with respect to the location of research • Coordination issues may become greater, so an important test is whether the benefits outweigh these costs	• More chance of finding expert solution to problem (buying research rationale) • Potential loss of spillovers unless market is reciprocal
Evolving, e.g. when regional groupings develop because of common interests and scale of problem		
Why not global?	• Costs of coordination and risks such as free riders may become more evident • Key test is whether European rationale can be superseded by global to gain benefits of greater scale, scope etc, which outweigh the costs • In most cases governance framework for global approach is more complex to achieve • Question whether European combined position may gain more benefit than direct national	• Essentially same questions as for basic research but all issues pervaded by competitiveness dimension • Large firms already at global level so issue is what can attract them to invest in Europe

National level

The traditional rationale for **national or regional** support for research rests upon the concept of market failure. The main argument is that knowledge created has the properties of a public good, being non-rival in use (results can be used simultaneously by many users) and non-excludable (those who have not paid for it may still use it). Hence, firms under-invest (or fail to invest at all) in research activities that can provide a desirable return to society (social return), unless the return to the firm (private return) is sufficient to motivate this investment rather than alternative business strategies.[29] Governments also generally accept as their duty the creation of basic capabilities for research, notably through training.

Other market failures are said to arise from information asymmetries and the uncertainty (lack of knowledge of the outcome) associated with R&D investment and innovation more generally. The failures may arise in the rigidities and mistakes of innovation agents (firms, public agencies etc) and in the system itself through a lack of linkages and fragmentation between innovation actors[30]. These system failures include gaps in the innovation system or its linkages, the risk of becoming

29 Nelson R. R (1959) The simple economics of basic research Journal of Political Economy 67 pp323-348, Arrow K. (1962) Economic welfare and the allocation of resources for invention. In: NBER Conference, Princeton University Press, pp. 609–626.
30 Metcalfe J.S (1994) Evolutionary economics and technology policy, The Economic Journal 104 pp931-944; Edquist C(1997) "Systems of Innovation Approaches – their emergence and characteristics" in Edquist C (Ed) Systems of Innovation – Technologies, Institutions and Organisations, Pinter.

locked into obsolete technologies, and insufficient technological opportunities created by basic research. Coordination failures are another feature and one to which we shall return.

A related line of argument shows that basic research contributes to the economy and society not only through the traditional process of discovery revealed through open publication but also through the flow of trained people, informal networking, problem solving and development of equipment.[31] Since such benefits are almost always enhanced by proximity, governments may sponsor basic research within their borders with assumption that these spillover benefits will be captured within the nation, an assumption which is usually but not always valid.

When we turn to applied research, national or regional governments principally sponsor it as customers with the aim of supporting policy through better information (see section 3.3.4). They may also sponsor research support for SMEs with the aim of making them more innovative or to enhance survival rates, in the belief that such firms provide an important engine for renewal within the national economy. (In Europe, this justification has, in our view, often overemphasised the importance of start-ups and small companies and assumed sufficient prospects for their growth.)

European level

A specifically **European** rationale for basic research funding rests upon resolving the apparently conflicting concepts of cooperation and competition discussed in the previous section. Summarising again, the benefits of collaboration come from achieving scale or scope (the full range of needed complementary capabilities), while those of competition come from raising the standard by opening resources to a wider pool of applicants (the ERC rationale). However, the competition rationale only really works when there is a "common pot" of resources and mechanisms for reinforcing strengths. The incentive for nations or agencies to open their programmes to researchers from other countries is only likely under specific conditions, for example when:

- The aim is to attract expertise to the sponsoring country (usually with conditions that the research is at least partly performed there);
- A national team requires complementary skills or assets in a collaborative project that cannot be sourced nationally;
- The aim is to raise the national level or achieve better technology transfer through joint working with a higher-level collaborator;
- The national effort is sub-critical and not viable without foreign input;
- Symbolic action is required to reinforce political objectives (usually on a small scale).

The reason such cross-border funding for basic research is unlikely outside such special circumstances lies in the national rationale we have outlined above and particularly in the arguments surrounding spillovers and proximity. Altruism emerges only when it sustains the ecosystem. Governments, just like firms, do not particularly want the raw outputs of basic research. They seek to develop the knowledge base and other benefits that go with such research, within their own borders.

A quite different argument can attach to **applied research** at a European level. Here the results of the research are what matter. Since government is buying these results in the same way as it might purchase any other service there should be no inherent reason to remain within national borders other than constraints of information and supplier capability. We return to the applied research market below.

The point needs to be made that European level does not mean the same thing as pan-European or all-EU. There are many "variable geometry" possibilities which find their own particular rationales.

Global level

A challenge for ERA at a time of globalisation in general, and of corporate research in particular is to show that European level action is not simply a weaker version of a utopian goal of global cooperation. It is certainly true

31 Salter A and Martin B (2001)The economic benefits of publicly funded basic research: a critical review, Research Policy Volume 30, Issue 3, 1 March 2001, Pages 509-532.

that some topics are global in scope (climate change being the obvious example and nuclear fusion another well-established case). There are three reasons why a European rationale can persist in these circumstances.

- The first concerns governance. The governance and management of global projects can be highly complex and it is more efficient to work towards single European representation where there are not significantly conflicting interests within Europe.
- The second reason follows on, in that Europe may gain more weight in negotiations from a combined position. Similar arguments also pertain for applied research but here considerations of competitiveness are also present.
- A third reason is that the global approach may not emerge until there is regional leadership.

The global issue is also present in considerations of what environment in Europe is most likely to attract or retain globally footloose industrial R&D.

3.3. Actors in the research-friendly ecology

Research funding organisations driving up quality

By research funding organisation in this context we mean those agencies which have the role of distributing research funds and are accountable for their use. The full gamut of research funders includes business and government departments or agencies that purchase applied research to support their missions in a direct way. These categories are discussed elsewhere in this report. Here our focus is on agencies which support basic and strategic research either as their central mission. Most are research councils but we also include NGOs (mainly charities) that support (mainly medical) research. The national research organisation (e.g. CNRS, CSIC, CNR) mainly belongs with universities in our discussion but we also need to recognise the role of these bodies in distributing resources for research. Also included, of course, are the European Commission in the context of its management of the Framework Programmes, and the European Research Council.

The ERA Green Paper takes research programmes as its unit of analysis in this domain but we believe that additional attention needs to be given to the agencies which operate them. One aspect is the degree of influence they are able to wield on research policy and more broadly on research for policy. There are two somewhat overlapping representative bodies, EUROHORCS (European Heads of Research Councils) and the more formally established European Science Foundation, both of which seek to influence and advise on policy and to promote cooperation in basic research[32]. This landscape has been further complicated by the formation of the European Research Council. While ERC is formally charged with the direct support of individual researchers it is likely also to acquire a direct voice in research policy advice. New players will enter the European scene when the Framework Programme is itself managed by administrative agencies. In this situation there is a clear need for an umbrella organisation which gives a single clear message on behalf of this sector (and in negotiations at a global level).

We agree with the broad sentiment of the ESF/EUROHORCS submission when it argues that the essence of a successful research system is that it is driven bottom-up rather than top-down and that coordination for its own sake (rather than in the pursuit of a mission) is at the expense of necessary variety and researcher initiative. For the reasons argued earlier in this report we believe that cross-border-funding of basic research and contributions to common pots will be a niche activity targeted to specific goals rather than the norm[33]. However, a much greater opportunity to raise standards across Europe through competition can be obtained with much less institutional change. This is to promote common or cross-border peer review procedures with the aim of exposing all researchers to the standards and feedback of the best. Some smaller countries have already moved to completely foreign peer review, either for highly competitive large grants involving most or all institutions, as with the Linnaeus Grant Scheme in Sweden[34], or across the board as with the National Science Fund in Bulgaria. Opinion is divided as to whether foreign

32 ESF and EUROHORCS elected to make a joint submission in the ERA consultation http://www.esf.org/typo3conf/ext/naw_securedl/secure.php?u=0&file=fileadmin/be_user/CEO_Unit/CEO/Documents/Taskforce%20EuroHORCs_ESF_Green%20Paper.pdf&t=1201459046&hash=19f751fbe8ff091ecac317e1253188b4.

33 A good practice example is the NORFACE ERA-NET which promotes funding and policy cooperation in the social sciences.

34 European Science Foundation, Peer Review – its present and future state, Conference Report Prague, 12-13 October 2006.

peers are "harder" or "softer" than national ones and there could be a real ERA role in creating a European College of Reviewers to assist both in the identification of peers and in the support for quality of reviewing standards.

The role of charitable/philanthropic foundations is one which deserves greater attention within the ERA framework. Despite the very uneven distribution and present low overall level of such funding throughout Europe this sector is of growing importance in the research ecology. Their significance lies in:

- Being a potential source of new funding for research not constrained by public sector limits;
- Having the potential to be more flexible and innovative in their approach to research support;
- Providing a means of articulating the demands of citizens for research on particular topics in a more targeted way than public bodies can manage.

More generally third sector organisations provide an intermediary between both the public sector and researchers and the private sector and researchers which allows allocation of resources at arms length.

An expert group report and subsequent conference have indicated the needs of this sector for a more conducive EU-wide legal-fiscal environment for the operation of foundations, including the adoption of a European Foundation Statute.[35] The launch in late 2007 of the "European Forum on Philanthropy and Research Funding" is a welcome development but this impetus should be maintained and given more of an ERA focus.

Empowering universities

Universities' role within the ERA is addressed by another Group but here their contribution within the wider research and innovation ecology is examined. While there are a few Member States where universities are not the principal research performer of basic research, their central role in providing human resources for research and innovation is undisputed and emphasizes the need to coordinate policy for research with policy for higher education. Even in the divergent cases the research role is growing in significance, though in some cases inhibited by severe under-funding.

When we turn to interaction with other actors, the increasing importance of University third mission activities in Europe is particularly evident in the high tech sector with a growing number of university-industry collaborative links further spurred by supporting national and EU policies and programmes. This has been the focus of various studies, with at least eight dimensions[36] of knowledge production and transfer identified, namely human resources, intellectual property, spin-offs, contracts with industry, contracts with public agencies, participation in policy making, engagement in social and cultural life and public understanding of science. In defining the unique mix of the three missions they address, universities are influenced by historical conditions and their context and the functions which they are able to perform (mass tertiary education, professional specialized higher education and research and academic training and research).[37]

This together with the growing tension between codified and tacit knowledge, public and private knowledge, the social and economic knowledge functions and the general and more specialized roles which universities are balancing, highlight the difficulty in the ERA defining or assigning appropriate roles for universities in a top-down manner, let alone designing effective support mechanisms.

It needs to be recognized that this is a highly diverse sector, with a research intensive elite scoring well but not well enough in world rankings and a much larger body of institutions engaged in research but centrally focused on their education and regional roles (a key role as we shall stress in the section on cohesion below). At present many institutions are inhibited by their national regulatory or statutory environment from properly

35 Meny Y, Papaconstantinou G et al, Report by an Expert Group on Measures and actions to promote the role of foundations and the non-profit sector in boosting R&D investment Commission of the European Communities, September 2005.
36 Schoen, A. et al. (2006) Strategic Management of University Research Activities, Methodological Guide, PRIME Project 'Observatory of the European University', www.prime-noe.org.
37 Larédo, P., 2007, Revisiting the third mission of Universities, toward a new categorisation of university activities, Higher Education Policy, 20, 4, pp. 441-456.

adapting to the most productive role that they could play, and from embarking on strategies to improve their research performance. Governments need to offer a stable and supportive environment which at the same time encourages professionalization of university management.

Our central message here, therefore is to support the European University Association position on the Green Paper when it emphasises the central importance of replacing bureaucratic regulation with autonomy and accountability.[38] Until institutions can be certain of selecting their staff and their students and managing their own budgets they cannot develop strategies in any meaningful sense. The keyword here is empowerment.

Engaging business in ERA

Business plays a central role in the wider research and innovation ecology, providing the key link to innovation, being the largest spender on research overall and a main career destination for trained personnel, both as researchers and as future senior company managers, as well as a significant funder of the public research system. Existing firms have immediate and long term interests in the quality of the research system around them, and in its ability to work across the interface of knowledge exchange. Creation and growth of new firms in key sectors depends in significant part upon the qualities of this system.

Unfortunately, the arguments underpinning ERA have not excited or engaged large parts of European business.[39] This is because they are most immediately concerned with public policies, regulations and markets that affect their efficient operation and allow them to capture value from their activities. It is only in certain very large and fast moving sectors such as information technology, where the part played by the European research ecology is so evident, that the urgency of this initiative is really appreciated.

This is in no sense a denial by the business sector of the importance of research, strong research institutes or adequate public funding for research. At issue are perceptions of the likely success, impact and added value of initiatives launched at European level compared to those continued improvements which are being stimulated mainly at local and national levels and happening faster in other parts of the world.

Without more effective horizontal and vertical actions, the research ecology in Europe risks having one of its central pillars weakened as firms move to relocate their R&D activities closer to key markets in Asia and the USA. The effect of these trends will become more and more evident over time. This is not the place to repeat in detail the opinions of the Aho Group on creating an innovation friendly market. Nonetheless, many of its horizontal recommendations, concerning intellectual property and other regulations will affect the success of ERA and need attention as a matter of urgency. We discuss the vertical recommendations on market creation through procurement and other measures in the section on Grand Challenges.

The immediate impact of the public research system in attracting large scale corporate R&D and innovation activities is significant but its direct role can be overstated.[40] The literature and the Commission's own studies show that market factors and the broader networks of contacts nucleated by leading public research centres are more important. Nonetheless the role of the science base cannot be neglected – actions have to address both supply and demand.[41]

38 European University Association, European Commission's "Green Paper" on "The European Research Area: New Perspectives", Viewpoint from the European University Association (EUA).

39 BusinessEurope submission to the consultation on the ERA Green Paper.

40 Foray D and Van Ark B, Smart specialisation in a truly integrated research area is the key to attracting more R&D to Europe, Knowledge Economists Policy Brief n° 1, October 2007.

41 Surveys of R&D performing firms by IPTS indicate that market demand for new products and services is by far the most important factor influencing the level of R&D investment, while market access is the most important factor influencing mobile R&D location decisions (European Commission Directorate General Joint Research Centre and Directorate General Research, Monitoring Industrial Research: the 2005 EU Survey on R&D Investment Trends in 10 Sectors, http://iri.jrc.es/); Similar conclusions emerge from the USA where Thursby and Thursby (2006 - Here or there? A survey on the factors in multinational R&D location. Report to the Government-University-Industry Research Roundtable. Washington, DC: National Academies Press) have argued that in emerging economies market growth potential was most important. However, the quality of R&D personnel was most significant for developed economies and the role of universities was seen as important in all cases.

A further point to make in terms of engaging business is that around 70% of the European economy is in the service sector (including those services which provide added value for manufacturing) and which is largely untouched by the research system. Research itself is also increasingly carried out by specialised service providers. These knowledge intensive service activities represent a significant growth opportunity for the European Research and Innovation Ecosystem. Substantial mutual learning will be necessary to achieve the required level of engagement and benefit.

Of great concern is Europe's apparent inability to facilitate the growth of small firms to become global players. Policy at present is seen by business as hindering rather than facilitating such growth. One source of these difficulties is a political attitude which appears to celebrate smallness as some kind of virtue in business. No doubt there are market niches which can only support SMEs but in general success comes with growth. Policy needs to engage more with large firms, not only multinationals but the neglected group of truly medium sized firms with turnover in the €100 million order of magnitude which is finding R&D increasingly difficult to sustain.

Furthermore, to continue the ecological metaphor, small and large firms are interdependent. The principal customers for small firms are large firms and they need connections at the R&D stage to ensure that they develop appropriate innovations. Large firms in turn rely upon SMEs not only for their supply chain but also increasingly as a means of knowledge acquisition through open innovation. Despite these obvious connections few policies seek to utilise these natural pathways and some work in the opposite direction.

Business seeks to use the knowledge created by the public research system, creating a focus on the effectiveness of knowledge transfer. For ERA, the issues are whether such knowledge transfer works effectively across borders, and more effectively as a whole in Europe than in other parts of the world. Proximity is important: as we have argued this can be geographical or by other means such as alumni linkages.

RTOs and the market for applied research in Europe

The Green Paper uses the image of a single market for research in Europe but says relatively little on a sector for which the market concept has immediate relevance, that of Research and Technology Organisations (RTOs) [42]. Their primary function is to perform applied research for customers, which include mission-oriented government departments, agencies and the private sector. In the framework of open innovation and the ecology that we describe, there is a strong case for introducing appropriate measures, including both incentives and the removal of obstacles, to support the emergence of a fully functioning single European market for these research services. In practice, this market does not yet exist, while some European RTOs are already developing strong business interests outside Europe.

Large public, semi-public and private RTOs have developed European strategies but remain mainly locked in to dominant national and regional funding sources and labour markets. At the other extreme, (particularly in some of the new Member States) large numbers of small RTOs are unlikely to be competitive without substantial consolidation. Evidence has been provided to the expert group by the relevant membership association, EARTO, which consulted nine big RTOs, including most of those with significant core funding (see Box 3.1). This confirms that the research these RTOs perform for the enterprise sector is funded mainly within the national market.

42 The European Association of Research and Technology Associations (EARTO) uses a more specific set of definitions, seeing RTOs as organisations "which as their predominant activity provide research and development, technology and innovation services to enterprises, governments and other clients …". It also seeks to distinguish RTOs from universities, the predominant activity of which is education, and from enterprises, the predominant activity of which is the production and sale of goods and services. Finally EARTO uses a criterion of funding models by stating that: "RTOs are organisations with significant core government funding (25% or greater) which supply services to firms individually or collectively in support of scientific and technological innovation and which devote much of their capability (50% or more of their labour) to remaining integrated with the science base". EARTO White Paper 2007.

BOX 3.1: LOW LEVEL OF NON-NATIONAL ENTERPRISE INCOME FOR RTOS

- The 9 RTOs have a combined annual turnover of €5.8 billion.
- 57% of their combined turnover is income from the enterprise sector. There is great variation, however: 4 have an enterprise share in total turnover of less than 50%, another 4 have an enterprise share of over 80%.
- 72% of their total enterprise income is national (but 6 have a national share in excess of 80%) and 28% is international (with 6 having an international share of less than 20%).
- The share of non-national EU enterprise income shows an extremely skewed distribution: it accounts for more than 50% of international enterprise income for 7 of the 9, and for 4 of them the EU share is above 70%.
- Overall, non-national EU enterprise income accounts for less than 5% of total turnover and for less than 10% of total enterprise income.

RTOs in all their forms play an important role in the research and innovation ecology of Europe, filling a gap that some call the "missing mezzanine". Less footloose than international firms and with much greater awareness than universities of the realities of technology development and support, RTOs contribute to the geographical and temporal continuity that the research ecosystem requires.

Local presence can be justified by the tendency of SMEs only to work with organisations in close geographic proximity to them. Their presence in a region is an important element of absorptive capacity for knowledge and for its subsequent dissemination and application, a theme we shall return to in the following section on cohesion but one which is important for all regions. This is increasingly recognised by member states, for example Sweden where there has traditionally been limited public investment in supporting RTOs.

Cross-border income from governments is even less evident or negligible compared with that from enterprises. A number of factors may explain this. There may be over-specialisation in response to the needs of government customers which historically may have been part of the same ministry. Governments may be acting as proxy customers for the work RTOs do for local SMEs. They may believe that there are substantial spillovers involved in the accumulation of expertise, thereby offsetting the cost benefits of acquiring this knowledge from a source in another Member State. They may see the provision of an element of core funding as a justification for seeking their need for the type of research services sourced by competitive funding from the same source.

However, the argument in the previous section on rationales should prevail in most cases. Governments and firms are purchasing applied research services. Spillover benefits should not be a major factor in determining the source of these services: where the need for such benefits is real, it should be addressed by other means.

This is an area where ERA can make a real contribution. Competition regulations mean that a Single Market exists in theory. Clearly, this single market does not yet exist in practice. An expanded market would encourage a process of cross-border rationalisation and mergers. It is surely the case that the larger institutions will be better equipped to maintain and configure the array of skills and capabilities needed to solve clients' problems more effectively. Competition should also raise the standard and lower the price of services available. This would not necessarily mean a loss of local presence. Dealing with SMEs and knowledge sharing in particular may depend on local outlets but these may still be more effectively managed from a reinforced centre.

There are examples of good practice on which to draw. In the field of metrology, the evolution of the association of national standards laboratories from EUROMET to EURAMET and the accompanying EU programme iMERA (implementing metrology in the ERA) which coordinates research are expected to lead to the sharing of resources under a follow on. Even now, this is happening bilaterally between some of the larger laboratories. Since the same standards no longer have to be supported by research in multiple sites, joint programmes and arrangements for traceability lead to an overall freeing up of resources and thereby improve effectiveness.

In terms of policy, the initiatives we envisage in public goods will offer a role for those RTOs specialised in such areas. This can help stimulate the emergence of a European market, and contribute to areas designated as lead markets. Along with the private sector, they are likely beneficiaries of policies that use innovative

procurement to stimulate the demand for R&D. ERA-NETs and JTIs too are a natural means to broaden the scope for commissioned research.

At a higher level, there is scope for measures to address structure and governance to promote development of the kind of scale that would facilitate pan-European operation. This could include facilitation of mergers, joint ventures, joint appointments and exchange of shares or Board Members. We note with sympathy the objectives of the EARTO proposal for an incentive scheme to provide a bonus from EU research funds on cross-border research contracts between accredited research organisations and enterprises (to counter national lock-in), while recognising that this needs careful study to ensure that it does not contravene competition and State Aid regulations.

Researchers

As with any profession, the driving goal for human resources in research should be to ensure that the workforce is well-rewarded, has a clearly-defined career structure (including pathways into and out of the profession), and is equipped with the training and capabilities that allow individuals to achieve fulfilment and to make an effective contribution to the goals of their employers. The needs of a research career are no different and the fact that large numbers of researchers across Europe fall short of these goals is a major source of weakness. On the other hand, the most successful research systems also have a competitive element in their career structures which allow the brightest and the best to find positions in environments that enable them to achieve their potential. The remaining researchers also have an important role in maintaining the research and training system as a whole and in applying their skills in other environments where their value can be appreciated.

ERA actions have focussed principally on transnational mobility, summarised as a "European labour market for researchers", but it should be remembered that many of the actions needed to make progress concern institutional reform in a variety of environments, notably in the employing research institutions and the wider situations in which these institutions sit. Mobility is not an end in itself but is seen as a part of the solution for researchers and also as an instrument for transfer of knowledge and building networks between types of institution: the source of researcher, the host institution and, if different from either of the first two, the next destination.

The relevant issues have been well-discussed by the specialist Expert Group on this theme. For the purposes of the research friendly ecology, we will highlight only two aspects, the need to tap a wider pool of talent and the unsolved problem of cross-sectoral mobility. On the first issue, the problems originate outside the research system in terms of attracting young people at school age into the science and engineering subjects that are needed for research careers. Gender issues remain a concern and one area of practical action is the reintegration of female researchers who have taken career breaks. There are also risks that research does not draw sufficiently upon the potential of socially excluded groups but here there is a need for further study.

On the second theme of cross-sectoral mobility, there is a clear need to meet the demands of knowledge circulation and exchange. The Aho Group noted that in a company the turnover between an R&D lab and other parts of the business was typically 10% of personnel and suggested that this could be a social benchmark for inter-sectoral mobility, notably between public research and business. If newly qualified researchers moving into employment are excluded, such mobility is probably more than an order of magnitude less than this level. This particular dimension of mobility is closely connected to the goal of fostering effective **knowledge-transfer**. The requirement is to achieve **permeable** institutions where the arrival and departure of researchers is a regular feature at every level:

- Through education and training prior to employment in other research institutions – such linkages often last an entire career;
- Through fostering temporary visits as with present mobility programmes;
- Through permanent part-time or visiting positions – a measure largely neglected by current policy instruments. Such positions often allow researchers of world-standing to spread their excellence through additional positions in other universities. This may be in peer institutions, as a device for creating concentrations at the research group level, or in less-advanced institutions where the distinguished visitor may have personal or cultural ties or simply be paid to help that institution keep in touch with leading edge work and in turn attract to itself bright early career researchers.

The key question for ERA is whether the transnational dimension addresses this need. Clearly it creates a broader pool of labour and of opportunities for those researchers and mobility programmes reinforce a natural tendency in research. However, the general desirability of the transnational dimension should not obscure the much larger scale of return that could be obtained if career structures and labour regulations were reformed to facilitate such cross-sectoral flows within as well as between nations.

We may also turn to the private sector to raise the question of broader global mobility, noting that the success of the US science system has been heavily dependent upon inflows of researchers from beyond its borders seeking positions and training with world-class groups and companies. In Europe too such phenomena are visible. The Philips Eindhoven establishment employs 59 nationalities and the Leuven-Aachen-Eindhoven triangle is aided through ERA-type policies. Philips has changed from being a closed centre to an open centre. There is a growing realisation that to perform well, companies have to employ people from outside Europe, and that movement of people into and out of the research laboratory is an important feature of their career development and the company's effectiveness. Europe, with its historic and cultural links to many emerging regions is well placed to act as a destination (temporary or permanent) for "footloose" research talent but more proactive measures to reduce barriers are needed within, and particularly beyond the domain of research policy.

Citizens

Our comments on the role of citizens as stakeholders in ERA will be brief and to the point. These are to endorse the Green Paper's statement that ERA requires that European citizens are well informed about all the issues at stake, and that there should be a spread of "research approaches geared towards society's needs and aspirations and of a culture and spirit of innovation throughout society as a whole." This is seen as an issue tied to communication, training and education. All of these we endorse but the central thesis of this report is that citizens are much more likely to form a positive engagement with research if it is clear to them that research is a key component in meeting society's economic and social challenges. To do this we propose the Grand Challenge model for ERA.

3.4. Cohesion and equity

This section explores the interaction between cohesion and competitive research and innovation policies in the context of ERA. We argue that optimum outcomes depend upon an articulation between supply and demand that will ensure that research capacity in less-developed regions primarily reflects the needs of those regions[43].

Cohesion policy remains a central objective for the EU and achieving this cohesion is critically dependent upon access to relevant knowledge. Research provides a key conduit for the flows of that knowledge. Consequently, ERA must facilitate such access by also encouraging the right kind of research investment in less developed regions. The effectiveness of the Knowledge Triangle relationship of research with innovation and education will be central.

The Structural Funds are seen as the prime instrument for promoting these goals. Improving research and innovation capacity in less-developed regions has already become a key element in the deployment of these funds, though this has not yet reached the levels appropriate for a knowledge economy.

The Aho Group report recommended a trebling of expenditure of the Structural Funds on innovation broadly defined. This has been largely achieved and is to be commended. However, in a number of Member States, including new ones where the need is greatest, the accompanying recommendation to invest a minimum of 20% of Structural Funds on RTDI has not yet been achieved. We recognise the value of initiatives from DG Regio and from the Framework Programme[44] but believe that a more strategic approach is needed on the part

43 For these purposes our definition of region is neither administrative nor statistical. Rather, we mean any sub-national space with the ability to take collective action to pursue common objectives of development. Even where there is no strong political competence or autonomy it is possible that institutions, firms and societal actors can work together to build strategic approaches.

44 Initiatives include INTERREG IVC, Regions for Economic Change and the Capacities Regions of Knowledge Programme in FP7. We also note the CREST Guidelines on Coordinating the Research Framework Programme and the Structural Funds to support research and development (CREST 1203/07) but stress the need to turn these into action agendas.

of the regions themselves, focused on use of Structural Funds based on an explicit articulation between knowledge supply and demand, with an emphasis on the valorisation and exploitation of knowledge.

A central concern for this report is what cohesion means for ERA. Is cohesion in research terms to be seen as an objective in itself or is it sufficient that the benefits of research and innovation are available in order to facilitate greater economic and social cohesion? One answer could be to treat research as a specialisation of a region like any other activity. On this view, it is absolutely to be expected that research will be concentrated in some parts of the EU, just as it is in the USA. California accounts for one fifth of US R&D, the top 20 states 85% and the bottom 20, 4%[45]; and the equivalent range for R&D to GDP (Gross State Product) also shows a wider variance than among nations in Europe.[46]

In reality, the choice between investing in research as an end in itself or as a means to an end, economic and social cohesion, is not so clear-cut. Investments in research, if implemented effectively, can create a number of spin-off effects – the development of local absorptive capacities, improved employability, the appropriate training in research of human resources, the development of networks and strategic partnerships, new research opportunities and research which address local needs and priorities, adaptation of technology to local context and innovative new products, processes and services tailored to the local context.

Almost irrespective of the intentions for economic and social development, societies will require a supply of trained people at a high level of education and skills with access to advanced knowledge. It is well established that practicing research at some level is needed for a community to remain in the networks which circulate new knowledge and to maintain the absorptive capacity to make use of that knowledge.[47] There is no reason to expect this situation to change, although this is not an argument for attempting equal distribution of public research investments. It is quite possible, for example, that a high tech installation or infrastructure will create little or no spillover effects in a rural region (recalling here the arguments we presented on related variety). All regions require institutions that are engaged with their own context. In a rural region, for example, this might mean a focus on biotechnology relating to the agricultural activities specific to that region. If these institutions also contribute to the provision of higher education, there is a good chance that related subject areas will also benefit and a core of local excellence be created, providing the basis for reducing exclusion from absorptive, agglomeration and diffusion effects.

A key challenge for such regions is to attract and retain high quality researchers and educators. Mobility programmes that concentrate on research alone can, at least in their early stages, have the reverse effect as they tend to move people towards existing centres of excellence. For a less-developed region, a better strategy is probably a strong focus on higher education to maintain the supply of new entrants and measures to attract back, or at least maintain strong networking connections with, the diaspora, through visiting positions etc. Regional and national loyalties can reinforce such strategies. Key factors in the emergence of China in research-based activities have been the phenomenon of 'returnees' mainly from the USA and the on-going flow of key personnel with bases in two regions.[48,49]

Cohesion is also a matter of knowledge flows. We note the work of the ERA Panel on knowledge transfer with its focus on intellectual property and open access issues. Other dimensions are also important. Knowledge flows from research to innovation (and vice versa) as much through informal channels as it does through formal

45 Bennof R.J., R&D Spending is Highly Concentrated in a Small Number of States, National Science Foundation, Division of Science Resources Studies, Data Brief, March 23, 2001.

46 Nonetheless US administrations over a long period have not considered this a satisfactory situation and seven Federal Agencies operate an Experimental Program to Stimulate Competitive Research (EPSCoR) to distribute R&D funds to talented researchers at universities and non-profit organizations in areas that have historically not received significant Federal R&D funding. These areas include 21 states and the Commonwealth of Puerto Rico. EPSCoR helps researchers, institutions and regions improve the quality and capability of their research in order to compete more effectively for non-EPSCoR research funds.

47 Cohen W.M. and Levinthal D.A. (1990), "Absorptive capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, Volume 35, Issue 1 pg. 128-152.

48 Normile D, Scientific Workforce: Many Overseas Chinese Researchers Find Coming Home a Revelation, *Science* 22 September 2006: Vol. 313. no. 5794, pp. 1722 - 1723.

49 Saxenian A, The New Argonauts: Regional Advantage in a Global Economy (Harvard, 2006).

publication and licensing arrangements. Again we return to mobility, though this can at its simplest mean the normal flow of graduates from higher education into business (and public services) taking with them up to date skills and knowledge. This places a focus on appropriate curricula and standards in HEIs. Networks and bilateral informal advisory and consulting arrangements are also an important part of the picture. Any remaining legal or other barriers to these should be dismantled immediately.

At a higher level of organisation, there are good examples of local ecologies which could fit well into an ERA based upon collective research. For example in the Valencia region of Spain, private non-profit research centres have proved a highly successful means of transferring new knowledge to SMEs[50]. Models exist both for sectoral specialisation (the old research association model) and technological specialisation. Such collective research plays an important role in intermediating between supply and demand for knowledge and in developing 'common pot' resources. Some caveats apply here:

- The desired emphasis lies in the end-use of knowledge, and this requires the effective intermediary to change its approach as levels of sophistication among the user community improve;
- Several efforts to reproduce such organisations have not been successful meaning that a better understanding of the conditions for their successful establishment and growth is needed;
- Such development is primarily a regional or national responsibility, though it should be a priority for Structural Funds.

The role of RTOs is also one of diffusion of knowledge. The recent food and agricultural foresight report from SCAR[51] found that the principal deficiency was not the production of knowledge from research but the accessibility of that knowledge to end-users, including in that case farmers. Also the lack of a feedback mechanism for such users led to research priorities failing to take account of their needs.

History favours the approach we have outlined. Mazzoleni and Nelson have analysed the structures supporting economic catch-up in a variety of situations, including Japan, Brazil, Korea, Taiwan and the USA throughout the 20th Century.[52] They conclude that public research institutions, often but not always connected with universities have played a central role. Rather than following the linear-model/spin-off approach they find that the most effective contribution came from research programmes in application-oriented science and engineering with a problem-solving orientation and working with a well-defined user-community. They also conclude that such institutions will be even more important in the future.

In summary we may return to one of our central themes. The effective use of research to support the achievement of cohesion depends upon achieving an articulation between supply and demand which ensures that research capacity in less-developed regions reflects the needs of those regions. This can only be achieved by a strategic approach formulated in the regions themselves. The ERA dimension comes afterwards as a means of enhancing the flows of knowledge into and out of those regions by providing a natural conduit for opening programmes and connecting to firms and research institutions in other countries. Better networked institutions are also more likely to be able to attract and retain the talent they need to thrive.

50 See for example the case study of the INESCOP research centre specialising in footwear and related industries in PREST, CSI, CSIC and SISTER (2002) A Comparative Analysis of Public, Semi-Public and Recently Privatised Research Centres, http://ftp.cordis.lu/pub/rtd2002/docs/ind_report_prest2.pdf Having formed a local market and built capabilities many such centres move on to sell their services to firms outside their original locations.

51 Gaudin T et al, Expert Group Report for Standing Committee on Agricultural Research, FFRAF report: foresighting food, rural and agri-futures, 2007, http://ec.europa.eu/research/agriculture/scar/index_en.cfm?p=3_foresight.

52 Mazzoleni R and Nelson RR, Public research institutions and economic catch-up, Research Policy 36 (2007) 1512-1528.

4. Driving ERA through linking research to the Challenges facing Europe

4.1. The European tradition

Europe's technological and industrial leadership has often been a consequence of rising to meet grand challenges – global scientific leadership in high energy physics and at CERN, the ubiquitous use of nuclear energy in France, economic leadership and widespread implementation of wind energy, GSM as a global standard, strong positions in aeronautics, space, etc. The list goes on. All of these have involved public/private partnerships, not only in their funding but also in the construction of markets through effective regulation and sound use of procurement. Even beyond Europe, in the USA and Japan a long list of breakthrough innovations that have shaped the world have emerged from grand challenges and coordinated efforts – semiconductors, internet… This is not in any way to minimise the critical role of entrepreneurs, nor the importance of ensuring wealth creation instead of picking technological solutions, but rather to say that the conditions were created for them to seize opportunities.

In the tradition of Schumann and Monet, the growth of S&T in Europe becomes legitimate by demonstrating to the public and politicians that they make a key contribution to the problems that society recognises as central. Our core argument is that to move forward ERA needs to balance its current focus on structure and process with a greater emphasis on content and outputs. The motivation for the reforms and investments demanded by the friendly ecology will only come when such an association is made.

4.2. Grand Challenges to inspire support for research

The proposal we make is to focus continued effort on ERA by engaging with a series of Grand Challenges that capture the political and public imagination and connecting ERA with these challenges. So far, most of our discussion has been on the system and its players. There is a need for something more to drive ERA forwards if it is not to project an emphasis upon remedial measures for the public research system. To capture the imagination of the research community and its stakeholders we are proposing that the next stages of ERA are rolled out through a series of actions addressing the Grand Challenges facing Europe. These challenges are both economic and more broadly concerned with social and environmental goals. This approach can shift perceptions as well as focus from deficit to opportunity.

It is artificial to separate economic, social and environmental opportunities since they all involve business, government and other stakeholders. However, for convenience of discussion we could categorise them by their centre of gravity. In the economic sphere the necessary agenda has already been set out by the Aho Group. The need is for action and in particular for the high-level coordination which is needed to create lead markets through the synchronised mobilisation of instruments such as public procurement and regulation along with R&D initiatives. Some elements of this approach have begun to appear in the Joint Technology Initiatives and Technology Platforms. In order to avoid being grounded in supply-push origins, the initiatives need their demand-side features reinforcing in key sectors so as to extend beyond the supply of research to encompass the demand-conditions for innovation – the innovation-friendly market. There are several welcome developments on topics such as pre-commercial procurement[53] and lead markets[54], and the linkage to

53 Communication From The Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe, Brussels, 14.12.2007 COM(2007) 799 final.

54 Communication from the Commission to the Council, the European Parliament, The European Economic and Social Committee and the Committee of the Regions, A lead market initiative in Europe, Brussels 21.12.2007, COM (2007) 860 final.

research should become more explicit. We consider it would also be a good step to identify JTIs and Technology Platforms more closely with an enhanced ERA brand by renaming them to include the ERA prefix.

In the social and environmental sphere the challenges are also numerous, ranging from dealing with the causes and consequences of climate change, food and energy security, ageing society etc. For most of these the drive will have to come from governments. Of course all are present in the Framework Programme but this should be seen much more as **a catalyst for far larger efforts engaging the resources of Member States and partners in business and societal groups**. The rewards for coordination are high but the corresponding effort to launch such initiatives is also considerable and requires the highest level political commitment.

Other challenges are at present rooted in science and technology themselves and involve the collective ability to respond to opportunities in frontier science and to mobilise resources quickly on an adequate scale to deal with emergent fields such as nanotechnology and others as yet not perceived. There is a critical role for social science and humanities research both as a direct response to the challenges and in helping to position the broader societal effort needed. Again, taking a positive light the aim is not to reduce duplication and competition but rather to foster variety.

The ERA Green Paper acknowledged the need to identify jointly major challenges or opportunities relevant to all or many countries but requiring research efforts beyond individual national capacity and cited for example the work of the Technology Platforms, Joint Technology Initiatives and the European Strategic Energy Plan. It also acknowledged the need for engagement of a wider range of stakeholders in such initiatives, including society-driven as well as competitiveness-driven research.

What we seek now is to find implementation paths for such efforts. It is a critical part of the ERA Rationale that it should have a "content dimension" or put another way, that it should involve vertical as well as horizontal initiatives.

How can we move from policy rationales to policy actions? We have reviewed the main elements of the present argument in terms of sub-criticality and system failure. A key problem with arguments of sub-criticality is that they are too easily perceived as treating the research system in isolation rather than improving this system by understanding the linkages with its stakeholders – the general public, business, policymakers and society at large.

It is difficult for politicians to give high prominence to the health of the research system for any extended period, but governments in a number of Member States have nonetheless achieved this for several years. Future pathways for ERA can help them achieve more, and also help other Member States come on board, by emphasising issues that are dependent upon research and lie at the core of almost all societal concerns. In advance of budget reform and making the case for investment in knowledge generation and application, the linkage with these concerns must be made more explicit and the development of supporting infrastructure in Europe more closely oriented towards facilitating this approach. Sub-criticality is a risk that cannot be afforded when it reduces capacity to implement solutions to our key social and economic problems. Much depends on strong vision, foresight and shared strategy.

4.3. Implementing the Grand Challenges

Our recommendation to use the concept of Grand Challenges as a prime engine for driving and giving substance to the ERA initiative, is tabled together with a number of important qualifications. Grand Challenges should derive this name from the fact that they are of sufficient scale and scope to capture the public and political imagination, create widespread interest among scientific and business communities and NGOs and inspire younger people. They must be capable of acting as an important tool for percolating attention at all levels of society all the way down to civil society and the public at large. Grand Challenges should be few in number at any moment, although they will be subject, within our ecology approach, to the dynamics of birth and death. It is quite conceivable that not all the Grand Challenges selected will proceed successfully. Where failure becomes apparent and the Challenge does not stop of its own accord, mechanisms must be in place ensuring that the Challenge can be dropped and replaced by another. The introduction of a form of timed support could provide the solution here.

The selection of the Grand Challenges is of paramount importance and is critical to the success of this approach. A systematic method will be required, using strict criteria.

Applying these criteria is not likely to prove an easy task because of both objective and subjective aspects which will affect even the discussion of the criteria themselves. Prioritisation of Grand Challenges is also likely to prove a stumbling block in terms of whether to opt for more society-driven, education-driven, industry-driven, innovation-driven or research-driven challenges. Two broad sets of criteria, shown in Box 4.1, underpin the selection of the Grand Challenges, namely: **attractiveness** (broken down into relevance and the presence of a clear research dimension) and **feasibility**. Each criterion requires in-depth consideration in order to address its constituent elements and issues of appropriate balance between potentially conflicting ideals/principles (European vs. global, scientific vs. social priority; doability vs. ambition).

The **relevance** of a Grand Challenge can be ensured by demonstrating strong linkage to the concept of European added value. This is determined on the basis of the extent to which the challenge is truly a concern affecting a majority of Europeans; and sufficiently transnational in nature and not achievable by a single state or region and thus best addressed according to the subsidiarity principle. This is likely to correspond to a policy/strategy area that is already addressed at European level where the EU has been given a clear mandate/competence. But it is also important to consider other areas where there is substantial potential to extend the EU competence. This could include policy areas/concerns where this approach offers the only conceivable way to address recognisable barriers. In such key areas, it is important to focus on those niches where a minimum critical effort is required that cannot be achieved without European cooperation and where there is a specific advantage for European industrial or other actors to work together in the framework of that challenge.

The risk entailed in a Grand Challenge may be mitigated by breaking down the response into modules which can effectively be addressed at the meso-level. The relevance factor depends heavily on the marketing of the Grand Challenges, the language used and the orientation given: selling a Grand Challenge will often entail showing that despite tackling a challenge which is primarily global, pan-European, European Neighbourhood or regional in nature, there is an advantage to securing a distinctive European position.

To be relevant for ERA and vice versa the Challenge must evidently have a clear **research dimension**. Not only are the choice and appropriate focus important, the overall design and planning of the Grand Challenge exercise is crucial, to ensure the buy-in and engagement of the research community and to induce much-needed gains in efficiency and effectiveness. The Grand Challenge must in its scoping and formulation demonstrate a clear research dimension and in the approach and implementation, research must constitute a critical element of the response to the Challenge. It is important to ensure full and effective dissemination of the knowledge generated and efforts should be made to capitalise on the benefits, in particular to training and education and the development of convergence and outermost regions by securing access and absorption. The Grand Challenge initiative should also plan for further steps and investments for the appropriate and equitable commercial exploitation of results.

A second key criterion in identifying the Grand Challenges is that of **feasibility**, that is the extent to which the proposed economic and social investment is feasible and whether a viable economic case can be made. Here more specifically it is important to consider whether there is a sufficient research base of adequate size and quality in Europe from which to launch the initiative and whether the industrial capability or policy implementation capability in Europe is sufficient to enable the outcomes of the project/programme to be realised. The Grand Challenges can thus build on existing EU strengths and capitalise on relevant Technology Platforms, Joint Technology Initiatives and/or ERA-NETs, and, as they develop, the EIT and ERC[55]. Garnering the appropriate level of support and resources ultimately depends on the buy-in of all major groups of actors and stakeholders, including a clear appeal for the research community and designing an effective decision path that will mobilise the necessary resources. Whilst the Grand Challenges should be doable and based on achievable goals, they should nonetheless represent a level of ambition and vision, expand the human imagination and project some stretch targets.[56]

55 We would not expect ERC to indicate priority areas but breakthrough sciences that it supports could initiate or engage with the Grand Challenges.

56 While the Challenge itself should transcend individual projects, the path to implementation may benefit from more tightly specified approaches such as operationalising the project/programme to address the challenge in terms of SMART objectives (Specific, Measurable, Achievable, Relevant and Timebound).

The success of a Grand Challenge will depend on its impact and replicability. It should survive long enough to have evident impact and should ideally serve as the focal point for the launch of new types of actions and goals. It is evident that the selection of Grand Challenges should take place by consultation not decree. An open transparent procedure for defining the issues in a first round is required followed by a second round to define a specific call for action.

We see linkage with Grand Challenges as a permanent feature of ERA, although the nature of the process will change over time. The essence of our argument is to work towards a **transition** in attitude: away from the situation today, where for most of the public, European research is abstract and distant, to a situation where everyone understand why it matters and recognises what it delivers. Small European countries like Ireland and Finland transformed themselves in large part when the public understood the value of strong education and subsequently recognised that socially-responsible entrepreneurship and innovation would provide the only route to the future. We seek a mechanism today to achieve the next stage of transformation for Europe as a whole, through a research system that is evidently closely linked to social progress and economic well-being.

BOX 4.1: CHECKLIST OF CRITERIA FOR A GRAND CHALLENGE

Attractiveness

Question 1: Is it relevant to address at a European level?

- Does it show European added value?
- Is it based on an issue which is pan-European or regional within Europe e.g. Baltic/ Mediterranean?
- Does it correspond to a policy/strategy area that is already addressed at European level or has substantial potential to do so?
- Does it concern/have relevance for most Europeans?
- Is there a minimum critical effort required that cannot be achieved without European cooperation?
- Does it secure a distinctive European position in addressing a global challenge?
- Is there a specific advantage for European industrial or other actors to work together in the framework of the challenge?

Question 2: Is there a clear research dimension contribution?

- Is research a critical component of the response to the challenge?
- Does the challenge have the potential to mobilise the research community and induce gains in efficiency and effectiveness?
- Will there be benefits to training and education?
- Will the knowledge generated be accessible to others in Europe who might benefit (if necessary on commercial terms)?

Feasibility

Question 3: Is it feasible as an economic or social investment?

- Can projects/programmes be framed to address aspects of the challenge in terms of SMART objectives (Specific, Measurable, Achievable, Relevant and Timebound)?
- Do the achievable goals nonetheless represent stretch targets? Can a viable economic case be made?
- Is there a decision path that will mobilise the necessary resources?
- Is there a research base of sufficient size and quality in Europe from which to launch the initiative?
- Is there a sufficient industrial capability or policy implementation capability in Europe to be able to realise the outcomes of the project/programme?
- Is there buy-in from all major groups of actors?
- Is there clear appeal for the research community to become engaged?
- Does it capture the public and the political imagination?

5. Beyond the Grand Challenges, a closer link between European research and European policy

The Grand Challenges seek to inspire action in key areas for all the reasons that we have enumerated. However, this should not be allowed to obscure the need to seek the benefits of ERA across the full range of policies and regulatory responsibilities that Member States have agreed should be articulated at the European level. Our message is that there should be a much closer alignment between research that is carried out at a European level (FP and coordinated national research) and support for European policies. This is fully in keeping with our core message, that the basic objective of ERA should be to seek to maximise the value contributed by research in Europe to economic, social and environmental goals.

It is important to reiterate that this is not an argument that all European level research should be applied in nature. The promotion of excellence in research undertaken by the European Research Council and the building of capacity through mobility and infrastructure support are essential parts of the ecology we have described earlier and are needed to support the training and knowledge generation needs of applied and strategic R&D. Our concern is that more effective use should be made of the large remaining parts of the Framework Programme and the considerable body of national research which either is or could be administered on a coordinated basis through ERA-NETs and other instruments. We also recognise the role of the Joint Research Centre in meeting some of the policy needs that are described below but few believe that this institution, as currently structured has the resources or capabilities to meet more than a proportion of these.

5.1. Policy areas in which to seek more alignment

From the EU's origins in the Treaty of Rome but with increased emphasis in successive treaties, there has been a growing number of policy domains for which at least a part of the governance structure operates at a European level. While all such areas increasingly demand a joined-up approach it is convenient to divide them into **thematic policies** which have a clear technological domain and often an industrial sector closely associated with them (for example energy, transport or security); and **cross-cutting policies** which structure the environment and interact with multiple thematic policies, examples being policy for competition, regional development or innovation. Each has a different history of interaction with research policy but in our view all could benefit from an enhanced ERA approach. The detail of such an approach needs to be worked out separately for each case (again there is no "One-size-fits-all" and there are many variable geometries). In the following section we seek only to give some broad indications of the context for action. The thematic policies are summarised in Table 5.1.

As may be evident from Table 5.1 the situation varies considerably between policy themes. The nature of the theme and associated sector, the structures and levels of governance at which policy is made, and the degree to which research contributes to policy and is itself seen as a means of implementing policy all are different across the areas.

TABLE 5.1
EU Competence in Thematic Policies

Thematic Policies	Specific EU Competence	Developments
Environmental policy	Environmental protection; actions to preserve, protect and improve the quality of the environment, to contribute towards protecting human health, and to ensure a prudent and rational utilization of natural resources; by introducing the principle of integrating the environmental perspective into other policies and by defining sustainable development as one of the Union's tasks.	Regulations; RTDI needs are defined in Environmental Technologies Action Plan ETAP (EC 2004) and Climate Change. The major environmental challenges and associated policy goals have been formulated in the Environmental Action Plan 2002-2012. Working groups in environment and health, urban environment, soil, water, air quality, biodiversity, and scientific support to policy) in order to specify research needs and agendas for the future.
Energy policy	Atomic energy (Euratom Treaty; European energy policy driven by efforts to realise the Single Market	Main areas of research driven by joint interest in disseminating knowledge on renewable energy and energy efficiency. EU research agenda: large-scale technological issues: smart grids or hydrogen and fuel cells, reflected in the Strategic Energy Technologies initiative (SET). Around these new "technological missions", TPs and ERA-Nets and FP 7 energy research jointly managed by DG RTD and DG TREN.
Transport policy	Transport policy (Treaty of Rome). A major extension of competencies (Maastricht Treaty 1992) through Trans-European Networks (TENs) but mainly driven by the need to build new infrastructure. Transport technology research draws its legitimacy both from environmental policy and from transport policy; or from the environmental items on the transport policy agenda ("pick and choose").	Research in support of transport policy has received limited funding in the late Nineties. A revival of interest in European research with FP 6 and FP7. Research on transport technology and systems is less directly connected to transport policy due to long lead times for realising new transport systems. Thus policies to implement transport systems tend to be technologically conservative, e.g. Galileo. There is a "structural mismatch" between the inter-modal orientation of transport policy while technology research is still organised by modes. In Aeronautics: SESAR, Single European Sky, Clean Sky have a mission-like character and are derived from major challenges, requiring combinations of scientific-technological and socio-economic research. TPs: ACARE, major role in defining research agendas and national-level research and technology policy strategies.

Thematic Policies	Specific EU Competence	Developments
Information society and media policy	Mix of formal competencies ranging from Single Market and competition policy via research and technological development to cohesion and consumer protection.	The 'information society for all' initiative frames regulatory and research policies – the recent revision of policy agendas led to stronger emphasis on media. DG INFSO is the only DG currently with explicit active policy of linking its initiatives to other policy areas. DG INFSO established the Information Society Policy Link initiative five years ago for improving collaboration with other DGs. Significant parts of the ICT programmes in FP7 tied to challenges derived from the user perspective (e.g. based on the 'ambient intelligence' vision developed by ISTAG), whereas others have kept a strong S&T focus. Multi-level coordination on research-related matters, regular consultations have been established between national and European level (IST directors' forum), i.e. between DG INFSO and the respective research ministries. CISTRANA (national R&D policies) and 9 TPs and respective mirror groups are soft mechanisms for defining joint research agendas.
Agricultural policy	Agricultural policy one of the cornerstones of the EU (Treaty of Rome 1957).	Still by far the largest spender of European funds. Research agendas closely embedded in consultation processes with various communities. SCAR (Standing Committee on Agricultural Research) make references in their docs to FP, TPs, national policies and research performers. SCAR has initiated coordination actions on a number of fronts, identified priority areas for further collaboration and established a number of MS collaborative working groups. EU-AGRI-MAPPING to identify trends and needs in research. Foresight processes have played a significant role, sponsored DG Research (e.g. Agriblue) and with SCAR 2006 EG.
Industrial policy	By Council decision: industrial policy in 1972, a role reinforced in 1992 with the Maastricht Treaty.	European level policy important in terms of regulation, in the pharmaceutical, chemical and textile industry. Little explicit reference to research in the industrial sectoral policies, only indirectly through innovation and competitiveness issues, e.g. in the context of the recent lead markets initiative that comprise elements of demand-driven innovation policy. The CIP programme aims at fostering research and innovation in support of community policies.
Public health policy	Public health (Treaty of Amsterdam 1997) and consumer protection (Treaty of Maastricht 1992)	This area does not build on a strong European level thematic policy (health is still mainly a national policy domain). However, the most advanced Art. 169 initiative is in this sector, driven by the Member States' policy interests and has led to the formulation of a European research 'vision' and agenda.

Nonetheless, it is widely recognised that scientific knowledge in general and research in particular make critical contributions to policy through several mechanisms including:

- Pure scientific research to support the national science base (for example, astronomical research);
- Public information services (e.g. meteorology, air quality reports);
- Support for regulation and legislation either nationally or in international agreements (e.g. testing, analysis, forensics, environmental impacts, health and safety);
- Support for procurement (notably in defence equipment);
- Services for industry or agriculture (e.g. standards, calibration, technology transfer/extension);
- Support for policy (e.g. scientific advice on public health).[57]

It may be argued that ERA-NETs are already serving a coordination function in such areas, and indeed at least two of the four so-called vertical groupings in which 85% of ERA-NETs have been classified correspond to the above policy themes (25% in Environment and Energy; Industrial Technologies, Space, IT and Innovation 29%; and 20% Life Sciences) and involve policy actors (38% Ministries and 20% Agencies). However, there is a limit to what can be achieved with this instrument. A positive evaluation has concluded that:

> *"ERA-NET fulfilled a real need within the policy armoury of the EU in that it helped overcome barriers to the coordination of national and regional research activities, a vital step in the creation of a real European Research Area. Benefits included the facilitation of mutual learning; the coordination of policy responses to shared challenges; the establishment of critical research masses in key areas; and the minimisation of unintended duplication and redundancy."* [58]

but the Green Paper Staff Working Paper countered:

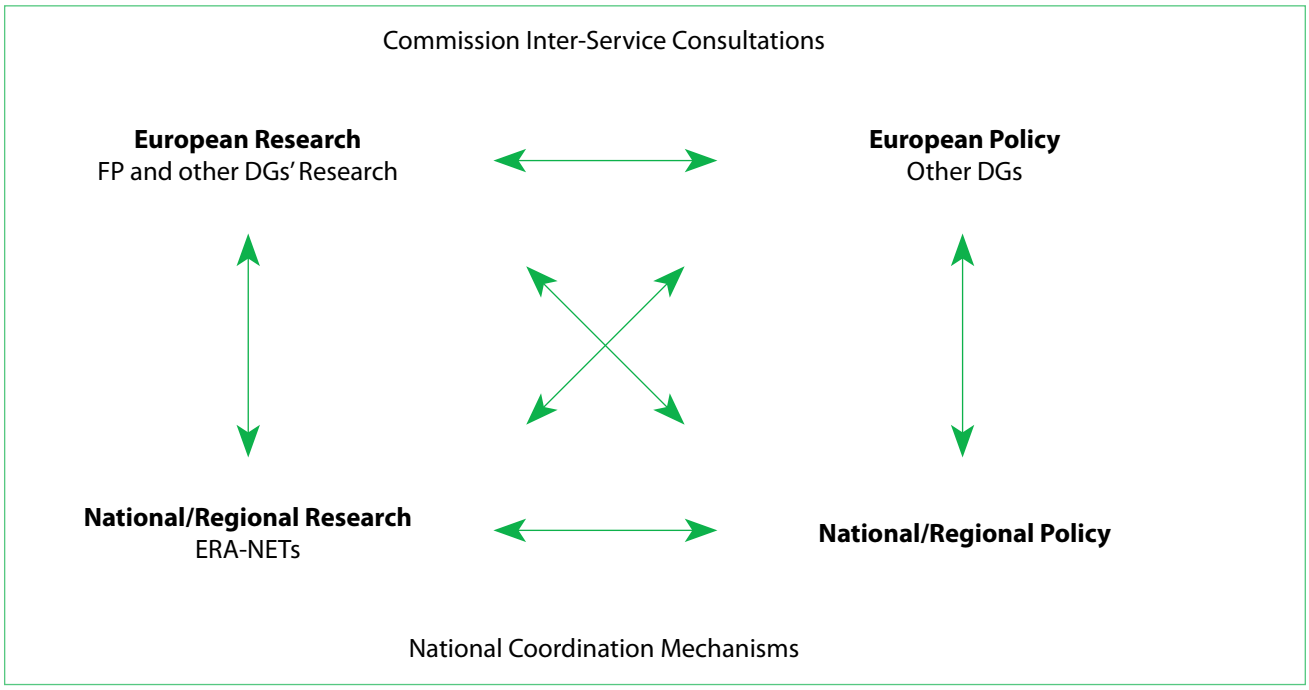
> *"Rather than as a tool for constructing coordinated research programmes, ERA-NET appears up to now to be mainly seen as a tool for information exchange and cross-border collaboration, in addition to – rather than restructuring or reshaping – existing tools. As such, it has also brought about a certain risk of creating additional fragmentation as it has in effect created an instrument for trans-national collaboration potentially overlapping with the existing ones."*[59]

For the purpose we envisage the need is for broader coordination which is both horizontal and vertical. Within the *horizontal* dimension of research this will extend not only to coordination across nations but also include the relevant parts of the Framework Programme and any other research funded by the European Commission (and other European bodies if relevant). In addition, there should be more *vertical* coordination with those responsible for setting policy in the area – the users of research through the modes described above. The problem is shown schematically in Figure 4.1. There is coordination within each box of the quadrant but much less across the boundaries and very little working simultaneously across all boundaries.

This is a very considerable challenge for policymakers and a problem which is generally not well-solved at national level either. There are more informal mechanisms, e.g. barriers between DGs are bridged by key individuals, who mediate for example between research policy and transport policy. Indirect coordination regimes such as technology platforms have also worked in this area though many have narrowed their scope to technological issues rather than engage with market structuring issues such as standardisation and regulation. Probably the best case examples are ICT and Agriculture. The first case is unusual in that policy and research are integrated within a single DG but a series of studies on intervention logic for FP7 have suggested that work remains to be done in understanding the linkages between research and wider policy objectives such as i2010.[60] In agriculture the Standing Committee on Agricultural Research appears more closely embedded in policy networks within and beyond research than its counterparts in other domains.

57 Boden R, Cox D, Georghiou L and Barker K Administrative Reform of United Kingdom Government Research Establishments: Case studies of new organisational forms, in Cox D Gummett P and Barker K (eds) Government Laboratories – Transition and Transformation, IOS Press 2001.
58 Horvat et al 2006 ERA-NET Review 2006 PII.
59 Commission Staff Working Document Accompanying the Green Paper The European Research Area: New Perspectives COM 2007 161, p42.
60 A recent Court of Auditors Report has also criticised the lack of intervention logic in European research programmes.

FIGURE 5.1
Dimensions of Coordination



Consideration also needs to be given to the cross-cutting areas mentioned above. Increasingly these have engaged with research and innovation, hence regional policy as noted earlier has acquired a strong element of innovation (primarily) and research content. Enterprise and innovation policy has a strong focus on SMEs and more recently a key initiative on the development of lead markets which among other benefits can pull through research. Market policies (competition and Single Market) in some senses may be seen to constrain research through limitations on State Aid but the debate is more about the detail than the principle as all parties see the benefits of competition. For all of these areas there is also the need for policy to be informed by high quality research, principally from the social sciences.

In summary, in this section we have extended our theme of developing ERA to shift the balance between supply and demand, by considering how to engage policy users much more in the process of defining research agendas. We do not advocate a crude customer-contractor relationship – this has been shown to promote short-term consultancy at the expense of real research. Rather we advocate a much more joined up approach which harnesses the improved supply potential that can be gained through cooperation and coordination to meet common needs of policymakers.

5.2. Metrics and reporting systems

It has not been possible within the scope of the Expert Group's activities to consider the detailed metrics and reporting systems required by ERA. We recommend that Commission Services, through the relevant consultative channels with Member States and other organisations, gives further careful consideration to this requirement. The principles that underpin many of the current reporting practices (based on the OECD Frascati and Oslo Manuals) were developed according to different assumptions of the purpose and practices of research, development and innovation, and in a number of respects these assumptions, principles and practices are no longer fit-for-purpose.

The essential features include the production of information that is internationally-comparable; actor-relevant as well as policy-relevant; and metrics that can encompass all relevant activities, rather than a set which are limited towards certain assumptions of what constitutes research or how research will be used. A key point is that, to date, most ERA statistics compare the nations of Europe rather than address the levels of cooperation and integration between them (or between regions at the sub-national level).

6. Conclusions and recommendations: Grand Challenges founded upon a research-friendly ecology

At the core of our recommendations is the need to provide ERA with a **clear purpose** which is **meaningful to Europe's citizens and political leaders** and is **relevant to its actors**. It is valid and important to improve the effectiveness of the public research system but the justification of the resources and commitment needed to achieve this lies in increasing the value of the contribution that research makes to Europe's economic, social and environmental goals.

The central means to achieve this is to engage the research system in **Europe's response to a series of Grand Challenges** which depend upon research but which also involve actions to ensure innovation and the development of markets and/or public service environments. The ability of the research system to play its part in meeting these challenges requires actions to meet the needs of the full spectrum of research performers and stakeholders. The needs for and the interrelationship between these actors and institutions are summarised in the concept of the **research-friendly ecology**. This in turn draws upon an analysis of the problems of sub-criticality and the balance between competition and cooperation required by such an ecology.

A step change in the quality of dialogue and linkages between supply and demand for research forms our third major theme, **the need to re-orientate strategic and applied research in Europe in close support of the full range of policies that Member States have agreed should be articulated at European level**. This involves the Framework Programme and national programmes, linked through ERA-NETs and other instruments engaging much more effectively with policy needs in areas such as the environment, transport, energy, agriculture and health.

None of our recommendations work against the measures proposed in the Green Paper. Current efforts to address deficiencies in the research system should proceed and be strengthened. Here we stress only some highlights of these but focus particularly on the additional needs and measures that are required if the research community is to make a compelling case for a real shift of resources in its favour in the forthcoming budgetary round and so be equipped to make its central contribution to the future economic and social well-being of Europe's citizens.

6.1. Driving ERA through linking research to Grand Challenges facing Europe

Europe's past successes have rested upon rising to meet Grand Challenges. Our proposal is to focus continued effort on ERA by engaging with a series of Grand Challenges that are of sufficient scale and scope to capture the public and political imagination. By giving ERA a content dimension, the Challenges must also inspire and motivate the research community itself.

The type of Challenges we envisage can be put into three categories, though there is considerable overlap:

- **Economic challenges** correspond to the agenda set out by the Aho Group and need to engage business through a combination of supply-side measures for promotion of RTD and demand-side measures to create innovation-friendly markets. A specific recommendation is that related initiatives such as JTIs and Technology Platforms adopt the ERA brand as a prefix;
- **Social and environmental challenges** deal with the causes and consequences of issues such as climate change, food and energy security and the ageing society. For these the initial drive will have to come from governments;
- **Science and technology** are also the basis of challenges involving the collective ability to respond to opportunities in frontier research.

Identifying Grand Challenges for support demands strict criteria as resources will confine them to a small number. Core criteria are:

- **Relevance** demonstrated by contribution to European-added value through transnationality, subsidiarity and the need for a minimum critical effort;
- **A research dimension** to ensure the buy-in of the research community and the potential to induce improvements in efficiency and effectiveness;
- **Feasibility** as an economic or social investment in terms of research and industrial capability and a viable implementation path.

A Grand Challenge requires the highest level political commitment as well as the engagement of business and other key stakeholders. It should be the norm that Grand Challenges are approved, announced and monitored at the level of the European Council, with the corresponding involvement of the Commission and European Parliament.

6.2. Building the research-friendly ecology

Achieving ambitious goals requires a research system capable of delivery and engaged with higher education and the innovation environment. An understanding of the roles and interactions between actors and the systemic features which promote or inhibit these is essential for the successful progress of ERA.

Overcoming sub-criticality and systemic failures

- **The perception of fragmentation has been a core part of the initial rationale for ERA**. This is composed of system failures at the level of governance to the extent that there is a lack of coordination or cooperation in research support, and of sub-criticality at the level of execution of research;
- **Sub-criticality is more important at the level of a whole institution and the institution in its setting than at the level of research groups**. Studies show that research groups function well with quite small numbers. Institutions with a wide range of capabilities are better able to configure themselves to address interdisciplinary problems and to work with business. Related variety reinforces and develops strengths. Sub-criticality may also relate to the demand-side when markets and the regulatory environment are fragmented;
- **ERA can address sub-criticality through promotion of networked specialisation and localised concentration**. Networked specialisation seeks to link groups with complementary capabilities. Specialisation should be promoted through competition for larger and longer term units of funding. Localised concentration places responsibility on the competent authorities in regions to effect mergers of institutions but ERA should support this by helping institutions to attract researchers and promoting cross-border knowledge flows;
- **The degree to which research is duplicated in Europe needs further research but is likely to be exaggerated** by aggregated statistics and reporting which do not reflect local adaptation and specialisation in fields such as biotechnology;
- **Competition is the prime driver of research excellence but too much becomes dysfunctional** because of its high transaction costs and a squeeze on the ability of institutions to develop autonomous strategies;
- **There is no one-size-fits all prescription for cooperation and coordination.** Each sub-field at different stages of its development has its own needs and the rationale for ERA promotion of linkages needs to be made on a case-by-case basis;
- **It is misleading to speak of a single market for research in Europe.** In reality there is a complex system of markets (at the corporate end of the scale and for scientific labour), quasi-markets (e.g. in attempts to commercialise public labs), and competitive allocation of public resources for research which do not operate on market principles.

Articulating the rationales for European level research

- There are key differences between basic and applied research in terms of the rationales for performing research at the European level. For basic research these lie in achieving economies of scale and scope,

accessing complementary skills and stimulating competition. Because governments principally support basic research for the spillover benefits that it induces in terms of training and knowledge accumulation, *cross-border funding is likely only in specific conditions*. For applied research where the motive is to purchase an expert solution the rationale for cross-border funding is an increased chance of obtaining that solution and in principle *there should be no barriers to a European market for research services*;

- **The principal arguments for not extending the concept of ERA immediately to global cooperation in research are** i) that governance of global projects is complex and can benefit from single European representation; ii) Europe may gain more negotiating weight from a combined position; and iii) a global approach may not emerge until there is regional leadership. There are also many issues which are specifically European (either pan-European or applying to a sub-set of nations or regions).

Strengthening the actors in the research-friendly ecology

- Research funding organisations require a more coherent voice in the European arena. Their influence is being limited by lack of a unitary umbrella organisation;

- **Common peer review offers more potential than common pots.** There is a clear opportunity to raise standards across Europe through more transnational peer review. An ERA role could be to create a European College of Reviewers to facilitate the process;

- **Charitable or philanthropic foundations deserve greater attention in ERA thinking.** Among their strengths is the ability to articulate demands for research from citizens;

- **The pressing need for universities is to replace bureaucratic restrictions with autonomy and accountability**. Universities play a crucial role across the range of ERA activities but their diversity needs to be recognised;

- The priorities for business in ERA are to achieve the innovation-friendly market envisaged in the Aho Group report and to engage in vertical actions for market creation that are a part of the Grand Challenge approach. Firms plays a central role in the wider research and innovation ecology but have not been strongly engaged with ERA;

- **The European research ecology requires the pathways between small and large firms to be reinforced.** Support initiatives should follow the supply chain and not attempt to target SMEs separately from their main customers;

- **There is a pressing need to open up the European market for applied research services**. Research and Technology Organisations fill in the "missing mezzanine" in the research and innovation ecology but have minimal cross-border business. Measures to stimulate mergers, joint ventures and other linkages are needed. Consideration should also be given to specific subsidies for cross-border business;

- At the level of individual researchers the principal needs are to tap a wider pool of talent and to tackle the unsolved problem of cross-sectoral mobility. More research is needed on the role of social exclusion from research careers. Cross-sectoral mobility is needed to meet the demands of knowledge circulation and exchange. The aim should be permeable institutions but national action to remove barriers must precede transnational initiatives.

Addressing cohesion through a localised articulation between supply and demand

- **Regions require research institutions that are engaged with their own context and local users.** We understand cohesion to mean access to the benefits of research and innovation but recognise that this cannot be achieved though knowledge transfer alone. Practising research, particularly of an applied, problem-solving nature, is needed for a community to remain in the networks which circulate knowledge and to achieve the absorptive capacity to use that knowledge. Ideally such institutions should also be linked to the provision of higher education;

- **ERA can reinforce knowledge flows into and out of regions** by providing a natural conduit for connecting to firms and research institutions in other countries. Better networked institutions are more able to attract and retain talent.

6.3. Creating a closer link between European research and European policy

- **There should be a much closer alignment between research carried out at a European level (both FP and coordinated national research) and support for European policies.** ERA benefits can be gained across the full range of policies and regulatory responsibilities that Member States have agreed should be articulated at European level. This argument does not apply to the ERC and other research where the principal goal is the promotion of excellence and capacity but it does apply to most of the rest of research currently conducted at European level;

- **Opportunities exist for research to support both thematic and cross-cutting policies**. In the former category are policies for environment, energy, information society and media, agriculture, industry and public health. Cross-cutting areas include enterprise and innovation policy and market policies. The application of research to support policy is a dimension which is not well-resolved either at national or European level. It requires both horizontal coordination between national and European users and performers/sponsors respectively and vertical coordination between users and performers/sponsors. This is a challenge that is core to ERA;

- **Commission Services should establish a specific unit tasked with fostering the connections among DGs and with their national counterparts required to achieve this vision of ERA.** The way forward here is not through creating crude customer-contractor relationships that have been shown to fail in other circumstances. Rather it is to promote meaningful engagement between the relevant parties to articulate supply and demand. Again there is no one-size-fits-all solution – the needs of each sector are different;

- **Responsibilities within Commission Services should be assigned in ways that highlights the strategic purpose of the European Research Area in respect of Europe's future economic and social development.** The traditional "funding agency" role of DG Research in respect of the Framework Programme can hamper the types of development that are set out in this report. We note the steps already being taken to place these tasks under "agency status", and encourage this process to continue and be further elaborated as the future rationale for ERA becomes more clearly articulated and accepted.

Annex 1 – Composition of the Expert Group

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Rapporteur

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Members of the Expert Group

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European Commission

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