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Policies to Build Research Infrastructures in Europe – Following Traditions or Building New Momentum?

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1 Introduction

Many European research institutions have a long tradition of excellence and European researchers continue to drive progress in many key areas of science and technology. Nonetheless, the persistent national fragmentation of efforts continues to prevent that existing research infrastructures reach a critical size and is arguably exacerbated by a lack of transnational cooperation between the existing sub-units of sub-critical size. Undoubtedly, this situation can be considered a serious obstacle to the development of European Science and Innovation in certain fields.

Despite this general fragmentation of the European research landscape, the evolution of transnational research facilities is nothing new in the European context and has evolved since at least the late 1950s. In earlier years, such co-operations have mainly been focused on the large scale laboratories needed in certain fields of fundamental science such as CERN, ESRF, ILL, EMBL, ESA and ECMWF. At that time, most of those research infrastructures were built on inter-governmental agreements defining shared contributions from a number of countries. Supra-national European Research Policies, in contrast, have typically been confined to supporting transnational access to existing large scale infrastructures and the funding of selected research projects aiming to raise their performance.

In the past decades, however, next to all research activities have become increasingly international endeavours, not only in the fundamental sciences but across the board. Hence, the need for international co-operation can no longer be regarded as limited to certain field of natural sciences. Against this background, new policy frameworks have been developed with the objective to establish a supra-national European Research Area in which a fragmentation of resources should generally be avoided. Hence, the aim to "develop world-class research infrastructures" has been declared a central objective of European research policy (European Commission 2008; 2010; [2012]). To help overcome the fragmentation of the European Research Area funding under the 7th Framework Programme is allocated to "optimise the use and development of the best research infrastructures existing in Europe" to thus create critical mass for all relevant scientific undertakings.

Against this background, this brief study seeks to establish whether the practical allocation of spending under the 7th Framework Programme's related activities can really be regarded as pursuing the objective of creating research infrastructures in an integrated way. In particular, it will document if such funding remains concentrated on a limited number of large-scale research facilities in technologically leading nation or if the factual reach of these programmes has actually been extended to other, technologically less advanced Member States. Furthermore, it will analyse whether the pattern of allocation to build and maintain large-scale research infrastructure is in line with the pre-existing structure of related funding under the 6th Framework Programme or whether the 7th Framework Programme has been taken as an opportunity to shift funding to build additional capacities in new, emerging areas of research.

2 Research Infrastructures as Elements of Supra-national Innovation Systems

As pointed out above, this paper will aim to explore the current and possibly future role of investment in research infrastructures in Europe. It will go beyond a mere listing of the respective support policies to achieve a more broad based understanding of the role that the set up and development of supranational research infrastructures plays for the emerging European Research Area.

As a foundation for this understanding we need to take a brief step back to the very foundations of the system of innovation concept.

As commonly known, innovation systems are defined by research performers, research facilitators (intermediaries), research governance agencies as well as the multiple and complex interactions between them (Edquist 1997; Lundvall 1992). The development of such interactions, in turn, is enabled and inhibited by a number of framework conditions that display a different degree of persistency. While some of them can be easily adapted by policy makers, others are of a socio-economic nature and can hardly be changed at all (Kuhlmann/Arnold 2001).

A supra-national system of innovation, as envisaged by European policy makers can therefore only then come into existence when the following conditions are fulfilled.

- Scientific activities are jointly conducted by teams composed of researchers from multiple countries of origin,
- A certain proportion of linkages both co-operative and with regard to human capital is realised across national borders,
- There is some sort of supra-national governance that sets relevant framework conditions for all research performers, irrespective of their country of origin.

The stronger those three claims hold true, the more meaningful the concept of a supra-national innovation system like the European Research Area becomes. Currently, however, there are limited number of studies on the structure and functionality of the European Research Area or, more generally, supra-national innovation systems. Instead, the main focus in the systems of innovation literature is on institutions at the national level and the examination of internationalisation at the system level (Bartholomew 1997; Carlsson 2006; Fransman 1999; Niosi/Bellon 1994; Niosi et al. 2000; Niosi/Bellon 1996). With regard to the latter, the degree of openness of national innovation systems was primarily analysed in the United States, Japan and leading countries in Europe, coming to four main conclusions.

Firstly, all types of international flows – both of knowledge and of commodities – are increasing and the rate of growth of some of them has been accelerating over the past decade, as globalization trends are gaining momentum. As a result, national innovation systems are empirically less "national" today than they were more than twenty years ago when the first related studies were conducted (Freeman 1987; Lundvall 1988).

Secondly, there are nonetheless wide national differences between countries in the rate and types of internationalization or globalization of their national innovation systems. Smaller countries are at the one end of the spectrum, with high levels of flows of scientific and technological knowledge and embodied technology crossing their borders, while larger countries are more self-sufficient and thus less affected by international technological and scientific flows.

Thirdly, different types of knowledge flows differ in their intensity. While different types of codified knowledge (patents and publications) enjoy a degree of internationalisation, researchers themselves still face notable obstacles to work-related migration. Further, scientific cooperation flows tend to be more intense than technological ones, reflecting both the non-tangible nature of knowledge as such as well as prevalent government support for internationalisation in public and semi-public research institutions.

Fourthly, the European Union with its project of the European Research Area remains the only major supranational integration area that has the set objective to build a supranational innovation system and a credible potential to do so. Japan and Chain are as such not internationalised enough (and demonstrate little political resolve to integrate) while the interaction between the U.S. cannot really be considered supra-national but at best bilateral – with one dominant partner. That notwithstanding, empirical evidence suggests that the level of integration in what is to become the European Research Area is still in many respects rudimentary – at least with regard to those countries that have not been part of the large nations established co-operation network.

Exploring formal integration related to S&T support, innovation and technology transfer and training and education, Caracostas and Soete (1997) have made a contribution to a description of an emerging European system of innovation. They conclude that "the process of post-national institution building in Europe has been characterized by "muddling through", by finding ad-hoc arrangements in a slow and incremental institutional change process, sometimes spurred by the political attainment of radical new formal

Treaties, but where compatibility with national rules and routines are a constant problem." For the time being, thus appears reasonable to regard the European Research Area as an emerging system of innovation, i.e. a system which so far only covers selected sub-systems and a limited number of partners in certain sectors.

In summary, the EU remains far from a full realisation of any the three conditions for a supra-national innovation system that we outlined above. In particular, the following challenges have yet to be overcome before a European Research Area can emerge:

First of all, the political landscape in research policy remains fragmented. Against the background of their limited supra-national jurisdiction in matters related to research policy, the Directorates General of the European Commission can only to an accordingly limited extend hope to address the common challenges in the supra-national area successfully. At the current point in time, it appears unrealistic to assume that national governments will yield more control and budget to the European Commission.

Secondly, the networks of co-operation and human capital exchange are typically fragmented or at least pre-defined by national boundaries resulting from issues other than legislation. Pavitt and Patel (1999) argue that innovative activities are significantly influenced by national systems of innovation in terms of: the local availability of quality research, particular skills, corporate governance, and business culture. A supra-national innovation system, therefore, can thus at best emerge gradually, even when all legal obstacles to human capital exchange and international research co-operation were removed at once.

Beyond these two foremost challenges, however, one further central issue remains to be addressed and has been acknowledged in the current European policy framework. It is related to the joint undertaking of research activities by international teams.

In some fields of science, technical requirements that stipulate a certain minimum size for e.g. large scale accelerator or nuclear fusion facilities to conduct successful world-class research. Accordingly, these necessities have prompted some key international undertakings from an early stage. Clearly, however, this field leaves room for further improvement with regard to efficiency as the current distribution of scientific activities suffers from a duplication of resources across national units of a sub-critical size.

A brief review of the literature on knowledge generation clearly suggests that the need for a certain critical mass cannot be understood on a technical level alone. Learning is a cumulative process so that all research teams in both the natural and the social sciences benefit from the increase in diversity and the broadening of the knowledge based brought about by an extension of the team. While the potential benefits are thus most evident for processes of learning that involve tacit knowledge, they apply as well to the accessibility of codified information. Clearly, centralised database will facilitate and speed up the preparation of studies. Finally, the centralisation of facilities brings advantages at a technical level since experiences the handling of the necessary equipment has to be made and the respective tests have to be run only once.

3 European Policy Approaches to Develop Research Infrastructures

Although most of the larger European nations invest heavily in research infrastructures, none of them can provide all the required facilities by themselves. Additionally, high investment and operational costs for large-scale research facilities tend to prevent a construction of satisfactory world-class facilities in smaller Member States. Thus, the fragmentation of national and institutional budgets restricts the flexibility and capability of all players to in sum develop "world-class infrastructures" at the European level. Against this background, it becomes obvious that a EU-wide effort to foster the supra-national establishment and operation of large-scale research facilities could provide an additional potential for the European Research Area – as long a all EU researchers are provided with full access to these infrastructures.

Clearly, however, the problem cannot be solved through the establishment of additional research organisations at the supra-national level. Except for the JRC of the European Commission (which remains small in terms of budget) there will be no fully Community funded research organisations in the foreseeable future as a political consensus for the creation of the necessary supra-national budgets is unlikely to emerge. Consequently, European policy makers have to rely on an enabling approach that convinces the member states to join forces in inter-governmental activities.

Within this framework, the Expert Group Report on European Research Infrastructures (European Commission 2010) rightly underlines that "there is little or no coordination between Member States of the prioritisation procedures they employ to determine how limited national funds should be allocated to research infrastructures on their national roadmaps, either for new infrastructures or for the continuing support for existing research infrastructures." As mentioned in more general terms above, this persistent lack of coordination between the Member States constitutes a major challenge, particularly with a view to the further development of the nascent European Research Area.

Despite all the obvious conceptual advantages of bundling certain types of research activities in a limited number of large-scale research facilities, it remains a politically sensitive task to address the current situation of fragmented national budgets from the

European level. Naturally, small countries are concerned that they may lose funding for the few existing capacities they have succeeded in setting up, resulting in a brain drain of national researchers to centralised European sites. Furthermore, even larger nations may fear to lose out in the competition with their strongest intra-EU competitors.

Against this background, this study aims to collect evidence with regard to the following two main research questions:

Firstly, whether the allocation of funding under the 7th Framework Programme's related sub-programmes remains concentrated on a limited number of large-scale research facilities in leading Member States or if the reach of these programmes to extends to other, technologically less advanced Member States.

Secondly, whether the pattern of allocations to build and maintain large-scale research infrastructures still follows the patterns of the 6th Framework Programme or whether the 7th Framework Programme has been taken as an opportunity to shift funding to build additional capacities in new, emerging areas of research.

4 A Review of Relevant European Policies to support Research Infrastructures

Up to today the Framework Programmes for Research are the main funding instrument through which European Research Policy supports the development of supra-national research infrastructures. Starting from the 4th Framework Programme for Research it has been a central policy objective to improve European researchers' access to large-scale inter-governmental facilities and research infrastructures. At that time, however, activities were not yet aimed at the creation of a supra-national research area.

A second important step was taken with the 6th Framework Programme for Research which – following the decisions on the ERA framework – broadened the scope of intervention by introducing a number of additional measures.

The first of these schemes, the **Integrated Infrastructure Initiative** (I3), was developed to better improve the access to important research infrastructures by means of concrete project-based networking activities. The networks thus created are aimed at the exchange of best practices, the organisation of training, access to and the development of new equipment. The FP supported networks are thus primarily targeted at "getting the most out of the existing facilities" by ensuring that scientists can access them effectively, and that the infrastructures remain up to the latest technological standards and the in line with the evolving needs of European researchers.

In total, the Integrated Infrastructure Initiative represented 50% of the funds (€730 million) devoted to the development of research infrastructures under FP6 (see also Table 1). Under FP7 the allocated budget has been increased to more than €1.7 billion. Support is available to infrastructures across all fields of science and technology including field-independent communication network development and a further extension of the existing GÉANT, GRIDS and Scientific Data Infrastructures.

While the optimisation and co-ordination of the use of the existing infrastructures is of central importance, new infrastructures are often needed to respond to the latest research needs and challenges. In the past, as pointed out above, many new infrastructures were planned and constructed without an overarching supra-national consultation based on national needs – even though a substantial share of their users would later be from foreign countries.

To overcome this obstructive situation the European Union set up the **European Strategic Forum for Research Infrastructures** (ESFRI) in 2002. The mission of ESFRI is "to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe, and to facilitate multilateral initiatives leading to the better use and development of research infrastructures, at EU and international level" (ESFRI 2008). The ESFRI delegates are nominated by the Research Ministers of the Member and Associate Countries, and include a representative of the Commission.

In more concrete terms, the ESFRI set out to develop a strategic roadmap with a view on the future construction of supra-national research infrastructures that was first presented in 2006. It was drawn up following wide stakeholder consultation and has been updated in 2008. So far it covers 44 RI projects which are considered vital for the future integrated development of science and innovation in Europe. By both the Member States and the European Commission the ESFRI-roadmap is now widely recognised as an essential basis for decisions relating to the creation of future research infrastructures based on inter-governmental funding. Recently, most Member States have begun to develop their own national roadmaps. The ESFRI national delegates, while representing their Member States views, play a crucial role on integrating and coordinating these national strategies with a view to a broader European picture.

Like the ESFRI, the **e-Infrastructure Reflection Group** (e-IRG) is a policy-oriented reflection group, composed of delegates appointed by the Member States ministries of research. It defines and recommends policies and best practices for the easy and cost-effective shared use of electronic resources in Europe (focusing on grid-computing, data storage, and networking resources). Additionally, it coordinates the introduction of a grid-based infrastructure for e-Science at European level. The key aim of the e-IRG is "to support – at political, advisory and monitoring levels – the creation of a policy and administrative framework for sharing electronic resources in Europe". While there is no strategic roadmap process, ideas and recommendations are summarised in a regularly updated white paper.

On the level of concrete support policies, these activities have been reflected in the selection of projects supporting the actual creation of new supra-national research infrastructures which as such pre-date the establishment of the ESFRI and the e-IRG.

Under FP6, two funding schemes had been developed to explore the possibility for the creation of future research infrastructures. The **Design Studies** Programme supports feasibility studies and the technical preparations needed for specific new research infrastructures with a European dimension and stakeholder base, including the needs of their potential future users. The **Construction of New Infrastructures** Programme provides support for the development of a limited number of concrete projects aiming at the construction of new or the enhancement and upgrading of existing infrastructures. Under FP7, the **Design Studies** Programme has been continued whereas the **Construction of New Infrastructures** Programme has ended. Instead, thirty-four projects identified in the 2006 ESFRI Roadmap are now supported in their preparatory phases. On average, the **Preparatory Phase** Programme allocates a €4 million grant to provide "catalytic support" with the aim to facilitate the construction of new or the enhancement and upgrading of existing infrastructures. Thus, the ESFRI Roadmap has become an important guiding framework for day-to-day support through the framework programme.

In summary, the activities supported under the past two Framework Programmes for Research can be distinguished into three main lines of actions:

- Support for the co-operation between existing research infrastructures,
- Support for new research infrastructures (including major upgrades), and
- Support for policy development and programme implementation.

Table 1: Overview of FP6-FP7 activities related to research infrastructures

<table>
<tr><th>Existing infrastructures</th><th>New infrastructures</th></tr>
<tr><td>Integrated Infrastructure Initiative:
Networks
FP7 – FP6</td><td>Design studies
FP7 – FP6</td></tr>
<tr><td>ICT-based e-Infrastructures</td><td>Construction of New Infrastructures (FP 6)
Preparatory Phase (FP 7)</td></tr>
<tr><td colspan="2">Policy Development / Programme Implementation
ERANETs and other support actions</td></tr>
</table>

Source: CORDIS, adapted

An overview of the respective policy measures is given in Table 1. The mentioned ERA-NET programmes relate to an overall co-ordination of national policy measures and will not be discussed in-depth in this5 paper since a more detailed discussion of this issue can be found elsewhere in this special issue.

In addition to the activities under the Framework Programmes, the European Union has adopted a regulation that makes available a new "easy-to-use" legal structure, the **European Research Infrastructure Consortium** (ERIC), which may be used by the interested research institutions throughout Europe. An ERIC is a legal entity based on EU law that provides the spirit of a truly European venture, a legal entity recognised in all EU Member States, flexibility to adapt to the specific requirements of each infrastructure as well as some privileges and exemptions allowed for intergovernmental organisations (VAT and excise duty exemptions, procurement rules) without having to go through the very complex process required for the creation of such an organisation.

5 Data: The current Research Infrastructure Landscape in Europe

With a view to the following analysis, it needs to be taken into account that the term "research infrastructures" describes a broad array of often quite different institutions.

On the one hand, they can be distinguished by the functions that they fulfil. Some aim to create critical mass for actual research activities in certain fields, whereas others aim to provide unique research services to users from different countries.

On the other hand, the political sensitivity of the issue and the fact that given structures and networks cannot be changed overnight suggests that in its political use the term "research infrastructure" does thus not only relate to large scale facilities at one given location, but also extends to co-operations that combine resources from a number of independent sources for a certain time-limited project. In that sense, bi- and multilateral links between national research organisations such as CNRS (France), CNR (Italy), MPG (Germany), and the UK's Research Councils as well as international teams of researchers under the umbrella of the Associated European Laboratories can also be considered "research infrastructures".

Against the background of that variety, few studies provide a reliable overview of the European landscape of research infrastructures in the broadest sense of the term.

There is, however, one representative study based on a survey of 598 organisations (European Commission/European Science Foundation, 2007) that can in this sense be drawn upon in this study. In that survey, the term research infrastructure was defined as "facilities, resources or services that are needed by the research community to conduct research in any scientific or technological fields".

With a view to the functions that they fulfil, it thus covered:

- Major equipment or group(s) of instruments used for research purposes;
- Permanently attached instruments, managed by the facility operator for all users;
- Knowledge based-resources such as collections, archives, structured information or systems related to data management, used in scientific research;
- Enabling Information and Communication Technology-based infrastructures such as Grid, computing, software and communications;
- Any other entity of a unique nature that is used for scientific research.

With a view to the second main differentiating issue outlined above, another document (European Commission, 2010) differentiates between:

- 'single-sited' physical facilities (a single resource at a single location),
- 'distributed' (networks of distributed resources, co-operations of existing agencies),
- 'virtual' ('virtual' access to a core facility is provided electronically).

Examples may include singular large-scale research installations[1], 'test-bed' facilities, collections, depositories, special habitats, libraries, databases, biological archives, clean rooms, integrated arrays of small research installations, high-speed communication networks (e.g. Géant), networks of computing facilities (e.g. Grids), research vessels, satellite and aircraft observation facilities, coastal or natural observatories, telescopes, fusion energy demonstrators, synchrotrons, as well as infrastructural centres of competence which provide a service for the wider research community based on an assembly of techniques and know-how.

1 The European Commission defines large-scale research infrastructures as those facilities with: large research capacity, trans-national relevance, requiring sizeable investment and, generally, having high operation costs. They may be unique or rare, and have a consequential impact on science and research at both the global and European level.

Table 2: Overview with the main characteristics of the surveyed organisations

Construction costs (av. per facility)	60 M€
Operational costs (av. per facility)	1-10 M€
Source of Funding	Main sources for construction: national public funding For operation and use: international and public-private funding more common
Permanent scientists	25.500 (lower estimate)
Users	240.000 scientists per year using these facilities
Countries DE-FR-IT-UK	40% of all facilities are located in these countries ¾ of all large facilities (> 250 M€ construction costs) belong to institutions of the respective Member States

Source: European Commission/European Science Foundation 2007

Before a further analysis is conducted, the nature of the sample shall be presented in some more detail.

An overview with more general characteristics of the surveyed organisations (Table 2) emphasises the abovementioned dominance of large, technologically more advanced Member States in the field of establishing and operating key research infrastructures. For instance, 40% of all facilities are located in the 4 largest EU countries France, Germany, United Kingdom and Italy. Moreover, ¾ of all large facilities, defined as those with high construction costs (> 250 M€), are located in these countries. The main sources of funding for the construction are national, for operation and use international and public-private funding are relevant as well. The 598 surveyed organisations employ 25.500 permanent scientists, 240.000 scientists are using these facilities per year.

Furthermore, more than half of the organisations in the sample (56%) were found to be fully public funded, with regard to construction costs the share even amounted to two thirds (Table 3). Nonetheless, the share of institutions co-financed from private sources is not negligible, amounting to 42% with a view to operational and 33% for construction cost. Fully private organisations, in contrast, remain a rare exception (1%/2%).

Table 3: Sources of Funding Public vs. Private

	public	**public-private**	**private**
construction costs	66%	33%	1%
operation costs	56%	42%	2%

Source: European Commission/European Science Foundation 2007

Moreover, the structure of the sample confirms that many research infrastructures are still funded and run from the national level (Table 4). In detail, 40% of all research infrastructures described themselves as primarily national, whereas only 11% were fully international scientific organisations. This share stands in contrast to the fact that more than 20% of research infrastructures in all fields are regularly used by more than 50% of foreign users (up to more than 50% in physics and astronomy). Non-surprisingly, a lot of joint funding is common among nominally national research organisation.

Table 4: Sources of Funding National vs. International

	national	international	Joint	other
construction costs	65%	7%	27%	1%
operation costs	51%	7%	40%	2%

Source: European Commission/European Science Foundation 2007

With regard to scientific disciplines, the majority of respondents were active in the fields of environmental, marine, earth Sciences (144), biomedical and life sciences (88) and materials sciences (85). Fields more intuitively associated with large-scale research infrastructures such as nuclear and particle physics, astronomy, and astrophysics contributed a smaller share (together 78).

According to the field of research in question, the nature of the research infrastructures differed strongly (Table 5). Whereas, for example, in energy research or physics where a large majority of research infrastructures remain single-site laboratories (96%/74%). The opposite, however, was true for the social sciences, where virtual networks have come to dominate (42%) over single-site research centres (32%). Finally, the field of environmental sciences provides an example of a research area where distributed and co-operative facilities play a major role (38%), arguably not least due to the networks of measurement stations that play an important role for that type of research.

Table 5: Scientific fields and organisational features of research infrastructures

	single-site	distributed/ co-operative	virtual
total	63%	25%	12%
Social Sciences	32%	26%	42%
Environmental, Marine and Earth Sciences	50%	38%	12%
Nuclear and Particle Physics, Astronomy, Astrophysics	74%	18%	8%
Energy	96%	none	4%

Source: European Commission/European Science Foundation 2007

Additionally, the study corroborated that the general attitude towards research infrastructures has changed (Table 6). Whereas in fields with an obvious technical necessity for large-scale facilities, i.e. physics, astronomy or energy research, most infrastructures exist for longer than 25 years, the majority of infrastructures in the fields of social and biomedical sciences is currently not older than 10 years. Interestingly, those two emerging areas of activity display the lowest bound of necessary investment for construction costs (21.8 M in social and 26.2 in biomedical science, in contrast to about 80 M in energy research, physics and materials science and 70 M in humanities).

Table 6: Salient features of research infrastructure per domain

	Character of Research Infrastructure	Staff
Nuclear and Particle Physics, Astronomy, Astrophysics	Old, upgraded, single-sited, high construction costs, national and international public funding	Substantial permanent staff, few remote and industry users, sizeable share of foreign users.
Material Sciences	Old, upgraded, single-sited, high construction costs, national and international public funding	Substantial permanent staff, few remote and industry users, sizeable share of foreign users.
Energy	Old, less recent upgrades than in other domains, single-sited, high construction costs, international and public-private funding	Average permanent staff, few remote users, sizeable share of industry users
Engineering	Single-sited, low construction costs, public-private funding	Average permanent staff, few remote users, sizeable share of industry users
Environment, Marine and Earth	Young, single-sited and distributed	Average permanent staff, few remote and industry users
Biomedical and Life Sciences	Young, single-sited but also distributed and virtual, low construction costs, national and international, public and public-private funding	Average permanent staff, few remote and industry users
Computer and Data Treatment	Young, virtual, low construction costs	Little permanent staff, many remote and few industry users
Humanities	a) Old, single-sited, high construction costs b) Young, virtual, low construction costs Both: National public funding	a) Substantial permanent staff, few remote users b) Little permanent staff, many remote Both: few industry users, less foreign users than other domains
Social Sciences	Young, virtual, low construction costs, national public funding	Little permanent staff

Source: European Commission/European Science Foundation 2007

6 Analysis of factual budget allocations

As outlined above, it is the aim of the following analysis whether the current pattern of allocations under the 7th Framework Programme appears conducive to support the creation of a European Research Area in which researchers, technology and knowledge circulate freely on an "internal market for research" and national and regional activities to build research infrastructures are co-ordinated effectively (Svanfeldt 2009).

To address our first research question regarding a potential undue focus of support activities, table 6 indicates the budget allocated for **I3 projects** by Member State and Framework Programme. Although the relative weight of the four largest EU countries (Germany, France, Italy and the UK) decreased from the FP 6 to the FP 7 funding period, 71% of the total budget of €370.7 million is still allocated to these four countries under the 7th Framework Programme. Among them France and Italy receive the largest allocations. When comparing the two framework programmes, it becomes nonetheless obvious that some of the smaller countries like Denmark, Finland, Norway and Greece are now to a greater extent among the beneficiaries than before. To the contrary, a significant decrease can be observed in the UK where the allocated budget declined from €96.7 million to €24.4 million. In addition, similar figures can be found for the main countries' role in project co-ordination (Table A1).

With a view to the first research question, therefore, the pattern of activity in I3 projects suggests that the four largest countries still dominate. Nonetheless, a certain shift to some of the smaller and medium-sized countries can be observed.

Table 7: Budget allocated for I3 projects co-ordinated by country

	Budget FP 6	% Budget FP 6	Budget FP 7	% Budget FP 7
BELGIUM	8.7	2.6%	0.0	0.0%
DENMARK	0.0	0.0%	7.8	2.1%
FINLAND	0.0	0.0%	5.4	1.5%
FRANCE	79.4	23.5%	92.3	24.9%
GERMANY	46.3	13.7%	66.8	18.0%
GREECE	0.0	0.0%	10.7	2.9%
ITALY	76.1	22.5%	80.2	21.6%
NETHERLANDS	17.5	5.2%	18.1	4.9%
NORWAY	0.0	0.0%	4.6	1.2%
SPAIN	0.0	0.0%	9.0	2.4%
SWEDEN	0.7	0.2%	12.4	3.3%
SWITZERLAND	12.1	3.6%	39.0	10.5%
UNITED KINGDOM	96.7	28.6%	24.4	6.6%
DE; FR; IT; UK	289.5	88.3%	263.7	71.1%
Total	337.7		370.7	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

Similar results are obtained, when the first hypotheses is tested with regard to **design projects**. Although their relative and absolute weight of the four largest Member States decreased from 70.3% to 56.8% (or from €98.5 million to €14.7 million) these countries are still the major beneficiaries of this type of projects they still obtain the lion's share of the funding – although the former singular focus on Germany has disappeared. Despite that, a number of smaller Member States could increase the share of allocations they obtained, including Spain, the Netherlands and Switzerland. As before, similar figures can be found for the main countries' role in project co-ordination (Table A2).

Table 8: Budget allocated for design projects co-ordinated by country

	Budget FP 6	% Budget FP 6	Budget FP 7	% Budget FP 7
BELGIUM	11.0	7.8%	1.6	6.2%
BULGARIA	0.0	0.0%	0.3	1.2%
FRANCE	11.1	7.9%	3.5	13.5%
GERMANY	67.8	48.4%	0.0	0.0%
GREECE	1.4	1.0%	0.0	0.0%
ITALY	12.9	9.2%	7.2	27.8%
NETHERLANDS	10.4	7.4%	3.6	13.9%
NORWAY	0.5	0.4%	0.0	0.0%
SPAIN	0.0	0.0%	3.2	12.4%
SWEDEN	3.0	2.1%	0.0	0.0%
SWITZERLAND	1.7	1.2%	2.5	9.7%
UNITED KINGDOM	6.7	4.8%	4.0	15.4%
Int. Organisations	13.7	9.8%	0.0	0.0%
DE; FR; IT; UK	98.5	70.3%	14.7	56.8%
Total	140.2		25.9	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

To further corroborate these findings, table 8 illustrates the structure of participants in both **I3 actions** and **design actions**. While the total number of project participants in I3 actions decreased from 813 (FP 6) to 577 (FP 7) an even somewhat more pronounced trend can be observed for participants from the four largest Member States (448 to 300) which thus reduced these countries' relative share from 55.1% to 52.0%. As regards the participants in **design actions**, the total number of participants declined from 244 to 110 while the number of participants from the four largest EU countries decreased from 160 to 60, thus falling from 65.6% to 55.5%. Thus, based on the number of project participants in I3 and design actions under FP 6 and FP 7 it can be stated that the integration of research infrastructures progressed in terms of an increase of the relative share of the medium sized and small countries. In more general terms, the

Gini-coefficient of the distribution of I3 funding across the EU 27 fell from 0.588 (FP6) to 0.558 (FP7), while for the design action it fell from 0.677 (FP 6) to 0.632 (FP 7).

Obviously, therefore, the data on project participation reveal of a gradual, even if not substantial decrease in the role of the European Union's four largest Member States. Furthermore, however, it has to be noted that the role of these key countries is less dominant with a view to the overall array of partners than it is with a view to the overall allocation of funding (cf. Table 7 and Table 8). Consequently, it is not surprising that the corresponding decrease should be less dynamic as well.

Table 9: Number of Project Participants in I3 and Design Actions under FP6 and FP7

	Participants in I3 actions		Participants in Design Actions	
	FP6	**FP7**	**FP 6**	**FP 7**
GERMANY	163	109	43	19
UNITED KINGDOM	84	82	48	21
FRANCE	102	61	36	10
ITALY	99	48	33	11
NETHERLANDS	52	42	14	9
SPAIN	45	28	19	12
POLAND	30	21	5	6
SWEDEN	31	19	14	1
BELGIUM	30	17	2	2
SWITZERLAND	23	20	6	5
GREECE	21	19	9	0
PORTUGAL	16	14	1	1
AUSTRIA	16	12	3	2
HUNGARY	13	12	1	1
DENMARK	13	11	3	1
FINLAND	13	10	2	3
CZECH REPUBLIC	12	8	1	2
IRELAND	14	5	3	1
ROMANIA	9	10	1	2
BULGARIA	8	10	0	1
SLOVENIA	4	5	0	2
SLOVAKIA	3	4	2	3
ESTONIA	3	3		
LATVIA	1	4	1	0
LITHUANIA	4	1	1	0
CYPRUS	3	1	1	0

	Participants in I3 actions		Participants in Design Actions	
	FP6	FP7	FP 6	FP 7
MALTA	1	1	1	0
TOTAL DE; FR; IT; UK	**813** **448 / 55.1%**	**577** **300 / 52.0%**	**244** **160 / 65.6%**	**110** **61 / 55.5%**
RUSSIAN FEDERATION	8	13	5	1
TURKEY	7	12		
NORWAY	10	6	4	1
ISRAEL	7	7	1	0
INO	12	0	3	1
UNITED STATES	3	2	3	0
AUSTRALIA	3	1	6	0
CANADA	1	1	1	0
GINI	**FP 6**	**FP 7**	**FP 6**	**FP 7**
EU 27	0.588219	0.557545	0.677049	0.632000
Total FP	0.724647	0.692319	0.682367	0.679292

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

In addition to the above considerations, we will with a view to our second research question analyse whether the selected fields are in line with the pre-existing European pattern of research infrastructures or whether the related actions of the 6th and the 7th Framework Programme have a recognizable tendency to disproportionally support emerging fields that have not received similar attention before.

To that end, the following Table 9 and Table 10 provide data for the number of project participants and budgets for I3 projects and design actions by field. Furthermore, the tables contain the breakdown of all research infrastructures per scientific domains based on the survey from the European Commission/European Science Foundation.

When the pattern of FP 6 / FP 7-allocations as well as participation is contrasted with the structure of the existing research infrastructure (in terms of the number of institutes) certain mismatches become evident straight away. In particular, it seems that the areas of physics and astronomy still enjoy a disproportionately high priority with regard to both I3 actions (nearly 40%) and design actions (above 60%) a situation that has not notably changed from the 6th to the 7th Framework Programme.

With a view to the secondary and tertiary foci of participation and allocation emphasis differs between the two programmes. With a view to I3 actions, environment and earth sciences continue to maintain a strong position with around a fourth of all participants and a fifth of allocations. Additionally, it displays a focus on life sciences which has notably increased from the 6th to the 7th Framework Programme. While only about ten percent of all activities and budget was devoted to these activities before, FP 7 has raised they relative weight to up to more than one fifth. With a view to design actions, the second most important field after physics and astronomy are the social sciences and area which received nearly no funding under FP6 but next to twenty percent under FP 7. Furthermore a strong new focus has been put on energy and engineering (11.6%/23.2%), a field which did not receive any notable support during FP 6 either.

While the 7th framework programme has moved somewhat more in line with the actual pattern of research activities in the EU 27, it still displays a strong, traditional focus on (nuclear) physics and astronomy and thus remains true to its origin. Nonetheless, the data indicate that the shift from the 6th to the 7th Framework Programme has not only brought an alignment with the factual structures but also moved additional, emerging fields – such as energy research and life sciences – in the focus of attention.

Table 10: Number of Project Participants and Budget by Field: I3 Actions under FP6 and FP7

FP6 / FP7 Area	survey		FP6		Budget FP6		FP7		Budget FP7	
Biomedical and Life Sciences / Life sciences	88	**15.9%**	75	**8.5%**	40.2	**11.9%**	133	**20.5%**	101.7	**26.5%**
Computer and Data Treatment / Mathematics and Computer Sciences	30	**5.4%**	20	**2.3%**	16.2	**4.8%**	10	**1.5%**	13.1	**3.4%**
Engineering / Engineering and Energy	30	**5.4%**	19	**2.1%**	11.8	**3.5%**	58	**8.9%**	43.3	**11.3%**
Environment, Marine and Earth Sciences / Environment and Earth Sciences	144	**26.0%**	249	**28.1%**	62.1	**18.4%**	165	**25.4%**	65.1	**17.0%**
Materials Sciences / (no such area in FP7)	85	**15.4%**	140	**15.8%**	92.8	**27.5%**	0	**0.0%**	0.0	**0.0%**
Nuclear and Particle Physics, Astronomy, Astrophysics / Physics and Astronomy	78	**14.1%**	345	**38.9%**	98.4	**29.1%**	245	**37.8%**	146.6	**38.2%**
Social Sciences and Humanities / Social Sciences and Humanities	98	**17.7%**	39	**4.4%**	16.2	**4.8%**	38	**5.9%**	13.8	**3.6%**
Total	553		887		362		649		383.6	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

Table 11: Number of Project Participants and Budget by Field: Design Actions under FP6 and FP7

FP6 / FP7 Area	**survey**		**FP6**		**Budget FP6**		**FP7**		**Budget FP7**	
Biomedical and Life Sciences / Life Sciences	88	**15.9%**	25	**9.0%**	15.8	**11.3%**	0	**0.0%**	0	**0.0%**
Computer and Data Treatment / Mathematics and Computer Sciences	30	**5.4%**	7	**2.5%**	1.4	**1.0%**	0	**0.0%**	0	**0.0%**
Engineering / Engineering and Energy	30	**5.4%**	5	**1.8%**	1.7	**1.2%**	14	**11.6%**	6.0	**23.2%**
Environment, Marine and Earth Sciences / Environment and Earth Sciences	144	**26.0%**	20	**7.2%**	6.0	**4.3%**	7	**5.8%**	0.9	**3.5%**
Materials sciences / (no such area in FP7)	85	**15.4%**	35	**12.6%**	36.5	**26.0%**	0	**0.0%**	0	**0.0%**
Nuclear and Particle Physics, Astronomy, Astro-physics / Physics and Astronomy	78	**14.1%**	181	**65.3%**	77.2	**55.0%**	75	**62.0%**	14.3	**55.2%**
Social Sciences and Humanities / Social Sciences and Humanities	98	**17.7%**	4	**1.4%**	1.6	**1.2%**	25	**20.7%**	4.7	**18.1%**
Total	553		277		169		121		25.9	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

7 Summary and Conclusion

As next to all aspects of research are becoming internationalised at a more and more rapid pace the need for the creation of transnational research infrastructures can no longer be seen as limited to certain fields of natural sciences. Against the background, new policies have been launched with the stated ambition of "developing world-class research infrastructures" through the creation of critical mass for scientific undertakings across the continent. Thus they seek to contribute to the establishment of a European Research Area in which the fragmentation of scientific resources can be minimised. Against this background, it was the aim of this paper to analyse whether selected policies with the aim to build capacity in this field are likely to contribute to their objective to help foster the emerging European Research Area.

Based on a recent representative survey of 598 European research organisations and available data for the 6th and 7th Framework Programmes for Research, evidence was collected to address two main research questions.

Firstly, we found that the four largest EU countries (Germany, France, Italy, UK) still dominate both lines of actions aimed at building or extending research infrastructures in Europe (I3 actions and design actions) with a view to budget, project co-ordination and, to a lesser degree, participation. Nonetheless, their dominance seems to subside gradually. In different respects, some smaller Member States have become better integrated in funding schemes of the 7th Framework Programme than they were under the 6th Framework Programme. Beneficiaries in that sense include Denmark, Finland, Norway and Greece. On the one hand, our findings thus illustrate that the aim to overcome fragmentation is clearly reflected in structure of the policy programmes while, on the other hand, they illustrate that a challenging task remains ahead.

Secondly, we found that the structure of expenditure and participation in the related actions under both the 6th and the 7th Framework Programme does not yet match well with the factual pattern of research infrastructures in Europe. Partially, that is due to the European Framework Programme's traditional focus on (nuclear) physics and astronomy that continues to take the largest share of all related allocations of funding. Additionally, however, there is evidence of conscious priority setting in new fields such as energy research and life sciences. Finally, the structure of allocations and participation under the 7th Framework Programme has come to reflect the factual pattern of research infrastructures in Europe better than was the case under FP 6, not least due to in increased acknowledgement of the role of the social sciences.

In conclusion, the European effort to build and strengthen key research infrastructures seems well on track to build new momentum although it is unlikely to overcome the persistent disparities across the continent in the nearer future.

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ANNEX

Table A1: Number of I3 projects co-ordinated by country

	FP 6	% FP 6	FP 7	% FP 7
BELGIUM	1	2.4%	0	0.0%
DENMARK	0	0.0%	1	2.6%
FINLAND	0	0.0%	1	2.6%
FRANCE	12	28.6%	10	26.3%
GERMANY	7	16.7%	8	21.1%
GREECE	0	0.0%	1	2.6%
ITALY	7	16.7%	7	18.4%
NETHERLANDS	3	7.1%	2	5.3%
NORWAY	0	0.0%	1	2.6%
SPAIN	0	0.0%	1	2.6%
SWEDEN	1	2.4%	1	2.6%
SWITZERLAND	1	2.4%	2	5.3%
UNITED KINGDOM	10	23.8%	2	5.3%
DE; FR; IT; UK	36	85.8%	27	71.1%
Total	42		38	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

Table A2: Number of design projects co-ordinated by country

	FP 6	% FP 6	FP 7	% FP 7
BELGIUM	1	3.7%	1	8.3%
BULGARIA	0	0.0%	1	8.3%
FRANCE	2	7.4%	2	16.7%
GERMANY	11	40.7%	0	0.0%
GREECE	1	3.7%	0	0.0%
ITALY	2	7.4%	3	25.0%
NETHERLANDS	1	3.7%	2	16.7%
NORWAY	1	3.7%	0	0.0%
SPAIN	0	0.0%	1	8.3%
SWEDEN	1	3.7%	0	0.0%
SWITZERLAND	1	3.7%	1	8.3%
UNITED KINGDOM	3	11.1%	0	0.0%
Int. Organisations	3	11.1%	1	8.3%
DE; FR; IT; UK	18	66.6%	6	50.0%
Total	27		12	

Source: own calculations, based on http://ec.europa.eu/research/infrastructures/index_en.cfm

Table A3: Laboratories and service providers as elements of research infrastructures

	single-site	distributed/ co-operative	virtual
laboratories	CERN, ESRF ILL, EMBL, ESO (Design Studies)	Integrated Infrastructure Initiative (some Design Studies)	
service providers		Integrated Infrastructure Initiative	EMMA-Net GÉANT (future) PRACE e-Infrastructure

Source: European Commission and European Science Foundation (2007)

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