EUROPEAN PARLIAMENT

DIRECTORATE-GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT A
ECONOMIC AND SCIENTIFIC POLICY

Economic and Monetary Affairs

Employment and Social Affairs

Environment, Public Health and Food Safety

Industry, Research and Energy

Internal Market and Consumer Protection

The Attractiveness of the EU for Top Scientists

STUDY

EN

2012

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Abstract

The study shows that while Europe has a strong science and research base the European research sector does not currently represent an attractive enough proposition for top researchers. To effectively address this problem, policies must be developed that specifically focus on the quality of the research environment while also creating the conditions that can best promote and reward scientific excellence. Opportunities exist at the EU level to positively address these issues, primarily in the context of targeted actions in relation to smart specialisation initiatives and specific actions in the framework of cohesion policy. There is a clear need also to strengthen the ERC and to streamline international cooperation with third countries in relation, for instance, to the Horizon 2020 initiative.

IP/A/ITRE/ST/2011-17 June 2012

PE 475.128 EN

This document was requested by the European Parliament's Committee on Industry, Research and Energy (ITRE).

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Original: EN

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Manuscript completed in June 2012.

This document is available on the Internet at:
http://www.europarl.europa.eu/studies

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LIST OF ABBREVIATIONS

AFs	Attractiveness Factors
BERD	Business Expenditure in Research and Development
C&C	The European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers
CEAIE	China Education Association for International Exchange
CIPE	Inter-ministerial Committee for Economic Planning
CNPq	National Council for Scientific and Technological development (Brazil)
CNR	Consiglio Nazionale delle Ricerche d'Italia
COST	European Cooperation in Science and Technology
CSC	China Scholarship Council (CSC)
CSCSE	Chinese Service Centre for Scholarly Exchange
CSIC	Consejo Superior de Investigaciones Científicas (Spain)
CTI	Swiss Innovation Promotion Agency
CUSPEA	the China-U.S. Physics Examination and Application
DAAD	Deutscher Akademischer Austauschdienst
DOE	Department of Energy (USA)
DPEF	Document of Economic and Financial Policy (Italy)
EEA	European Economic Area
EPSCoR	The Experimental Program to Stimulate Competitive Research
ERA	European Research Area
FAIR	Facility for-Antiproton-and-Ion-Research
FET	Future and Emerging Technologies
FCT	Fundação para a Ciência e a Tecnologia (Portugal)
FiDiPro	Finnish Distinguished Professor (Programme)

FSO Federal Office of Statistics (Switzerland)

FP6 The Sixth European Community Framework Programme for Research and Technological Development

FP7 The Seventh European Community Framework Programme for Research and Technological Development

FYROM Former Yugoslav Republic of Macedonia

GERD Gross Expenditure in Research and Development

GSRT General Secretariat of Research and Technology

HEI Higher Education Institutions

HERD Higher Education Research & Development

HRST Human Resources in Science and Technology

ICT Information and Communication Technologies

IISER The Integrated Information System on European Researchers

IIT Italian Institute of Technology

INL Iberian International Nanotechnology Laboratory

ISAP International education and study partnerships (Germany)

ISI Institute for Systems and Innovation

ITER The International Thermonuclear Experimental Reactor

KBBE knowledge-based bio-economy

MCTI Ministry of Science, technology and Innovation (Brazil)

MES Ministry of Education and Science (Russia, Russian abbreviation MON)

MEYS The Ministry of Education, Youth and Science (Bulgaria)

MIT Massachusetts Institute of Technology

MIUR Ministry of Universities (Italy)

NAAC The National Assessment and Accreditation Council (India)

NKTH Nemzeti Kutatási és Technológiai Hivatal (Hungary)

NPFRI National Programming Framework for Research and Innovation (Greece)

NSF National Science Foundation (USA)

OIF Outgoing International Fellowships

OSTP Office of Science and Technology Policy (USA)

PACTI National Action Plan in Science, Technology and Innovation (Brazil)

PRO Public research Organisation

RFFI Russian Foundation for Basic Research

R&D&I Research, Development and Innovation

RI Research Infrastructure

RIC Research and Innovation Council (Finland)

S&T Science and Technology

SAARC South Asian Association for Regional Cooperation

SBF Staatssekretariat für Bildung und Forschung (State Secretariat for Education and Research)

SCSP State commissioned student places

SHOK Strategic Centres for Strategic Centres for Science, Technology and Innovation (Finland)

SNF Swiss National Science Foundation

SSTC The Swiss Science and Technology Council

SWOT Strengths, Weaknesses, Opportunities and Threats (usually referred to as the method '*SWOT-analysis*')

Tekes the Finnish Funding Agency for Technology and Innovation

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EXECUTIVE SUMMARY

This study focuses both on the current policy regime and the prospects for the future in relation to the attraction of top international scientists to the EU and the retention of home-grown academic talent. The main research question is: "Compared to selected competitors, in both a range of emerging economies and in those with the most dynamic research environments (e.g. the USA, China and Switzerland), how attractive is the EU for top international scientists and how can the EU and its Member States improve their performance in this area?"

The approach used herein was based on a documentary analysis (both qualitative and quantitative) of previous studies and policy documents at both the EU and national levels (in relation to selected cases). The documentary analysis was also extended to include a number of third countries identified as the main competitors in relation to the attraction and/or retention of top scientific talent. These countries were the USA, Switzerland and the group of countries collectively referred to as the BRICs (Brazil, Russia, India and China). In addition, this approach was supplemented by a small number of exploratory interviews with top scientists with concrete experience of working in the EU and in these third countries. The aim here was to determine the main factors that influence top scientists when it comes to selecting their place of work and to examine how such factors are addressed by current policies and strategies at both the EU and the national level (in relation to the selected countries). This gap analysis enabled us to identify the various strengths and weaknesses of the policy frameworks currently utilised in both the EU and the national level contexts in relation to this issue and to develop recommendations with a view to increasing their attractiveness to top scientists at the international level.

The main challenges faced in the completion of these tasks included the lack of a suitable and commonly accepted definition for 'top scientists' and the lack of data characterising their mobility as well as information on the corresponding career development/progression mechanisms. An operational definition for 'top scientist' was used based on concepts relating to academic excellence, research production and various other criteria that enabled us to take into account the influence that they might exert in their own academic environment.

It is clear that the European scientific community is already one of the most productive in the world and that progress is being made in relation to improving the framework conditions for research professionals across the EU and in effectively addressing issues relating to questions of 'attractiveness'. The key remaining challenge however is to streamline efforts to better respond to the emerging worldwide competition for scientific excellence.

The USA provides an interesting and highly relevant benchmark for the EU. The focus on research *quality* as opposed to *quantity* seen in the USA relates, in the context of this study, to the quality and worldwide impact of the research produced. This is something which consistently marks out the USA as the destination of choice for top scientists.

The literature data and the findings garnered from the limited number of interviews undertaken in the context of our study show that top scientists are relatively mobile and oriented towards an international career. They are primarily attracted by knowledge stimulating research environments, research institutions that can compete at a global level and opportunities to raise large amounts of funds for cutting-edge research.

The level of remuneration may play a role in the way in which top scientists select their places of work and in this respect only a few European centres are in the position to match the salaries and other benefits offered by leading American universities. The non-EU countries analysed in our study are very active in their headhunting activities. The most successful competitors are generally able to provide a highly competitive remuneration package. This is then an issue that needs to be addressed more actively.

The lack of career paths for young researchers and the absence of a tenure track are often identified as the main barriers, in the EU countries, to attracting top international scientific talent. The wage level is also often seen as a competitive disadvantage. In some cases, the research system and/or environment is difficult to access from the outside with specific certification and language skills required as a starting point.

From the universities' perspective, the quality of their retained academic and research staff is seen the main factor in their ability to attract top researchers. The challenge for the EU countries and their universities is thus to focus to a much greater extent on quality and to become more selective, primarily by using a higher proportion of resources in research and education to attract future talent and through the consistent rewarding of excellence. National policies should target the development and promotion of the necessary conditions in public institutions to identify and reward excellence in research.

Some EU countries have already sought to address the quality of the research environment with universities and higher education institutions being given greater autonomy to set their own wage levels. If such measures are accompanied by a stronger focus on research quality and production this would increase the chances of these institutions being able to compete with leading universities in the USA and elsewhere. Another positive effect of this policy relates to EU-based universities' enhanced ability to attract the large pool of talented European researchers who have left the EU for destinations primarily in the USA.

The EU retains a significant potential in terms of the skills and infrastructure required to develop centres of worldwide excellence in a variety of sectors and disciplines. However, in order to be in a position to effectively compete on the international stage, it is essential for the EU and its Member States to join forces around a number of common objectives and to align the available funding instruments for research and innovation to such common objectives and goals.

In this respect, the current EU-wide initiatives on innovation, smart growth and smart specialisation should be directed towards creating research environments that would attract top researchers. Important parameters to be taken into account should include: the focus on research, funding for long-term and high-risk research, less administrative burdens, flexibility in terms of hiring highly qualified and promising researchers and the ability to offer attractive remuneration packages. Another suggestion that might have a very positive impact on the Convergence objective is the one initiated by the European Parliament on a competition linking stakeholders in less developed and advanced Member States with the objective of creating leading research centres in the former. If the attractiveness factors mentioned above are taken into account in the design of such centres there is a good chance that they will boost the innovation capacity and economic growth of convergence regions while, in addition, increasing their ability to attract top scientists.

The European research *Framework Programmes* have been designed to promote European excellence in research. This is also one of the objectives of Horizon 2020, the EU's new programme for research and innovation. Our study draws attention to the aspects of Horizon 2020 that can directly contribute to raising the attractiveness of the EU to top scientific talent: (a) Marie Curie and ERC grants have significant impacts on the integration of researchers and on enhancing and maintaining European excellence in frontier research.

These actions should be maintained and financially strengthened. (b) Horizon 2020 aims to support research collaboration and exchanges with third countries. Such international cooperation, particularly with the third countries discussed in the context of this study, should be developed on the basis of commonly defined strategies, objectives and mutual commitments in order to produce concrete results.

Very little evaluative information is currently available which effectively enables us to characterise 'top scientists'. In view of their importance in developing scientific and research excellence, there is nevertheless a strong need to develop more systematic studies and monitoring tools for (a) defining and identifying top scientists and (b) studying their mobility patterns. The creation of an analytical information framework such as this would enable us to better develop policies that would more effectively address the attractiveness of the EU and of the various EU Member States, in comparison with the leading international performers, thus providing a firmer basis from which to assess and fine-tune such policies for the benefit of European competitiveness in science.

1. INTRODUCTION

1.1. Background of the study

Access to highly trained and qualified researchers is a necessary condition for the advancement of science and to the underpinning of innovation while also being an important factor in the attraction and sustainment of further investments in research by public and private entities.[1] According to the Innovation Union Competitiveness Report 2011 "*its large number of researchers and skilled human resources is one of Europe's major assets*".[2] Concerns however arise in several Member States, because of the need – based on the EU decision set by the Barcelona European Council to invest an average of 3% of GDP in research[3] - to create, by 2020, at least one million new research jobs, a figure that is close to two thirds of the total number of European researchers in 2008. Moreover, the ongoing financial crisis and its accompanying recession have undoubtedly had a negative impact on research jobs in the sense that budgetary cuts in both the public and private funding of research are likely to make the Barcelona goal unrealistic for the foreseeable future, but at the same time the economic downturn may increase the attractiveness of research as a career opportunity.[4] Moreover, the actual number of researchers required will be even higher than the one million headline figure suggests, as this figure simply does not take account of the large number of researchers exiting the profession through retirement in the coming years.

The 2007 Green Paper[5] launched a wide-ranging public debate on how to create a more open, competitive and attractive European research area. A number of key areas have subsequently been identified where effective actions, undertaken in partnership between the Member States and the Community around common objectives would deliver significant gains for Europe's research system and help to create a "fifth freedom" in Europe – the freedom of knowledge. In 2008, a Commission Communication was published that proposed to develop a partnership with the Member States to ensure the availability of the necessary researchers.[6]

The Spring 2008 European Council confirmed the need to invest in people and modernise labour markets, while investing in knowledge and innovation were also seen as top priority areas for the renewed Lisbon Strategy for Growth and Jobs.[7] Significant efforts have already been made, with additional proposals planned, to transform the EU economy by directing it towards more knowledge-intensive activities, including measures to strengthen the single market, increase job mobility, to reinforce education and training, and to provide incentives for more private investment in research and innovation.[8]

1 European Commission (2011): Innovation Union, Competitiveness Report 2011 – Executive Summary, p. 4.

2 *Ibid*, p. 4.

3 European Commission (2008a) : Realising a single labour market for researchers, Report of the ERA Expert Group, Directorate-General for Research.

4 This varies from country to country as in many countries also the public research and the higher education sectors have faced tightening budget constraints.

5 European Commission (2007): Green Paper - The European Research Area: New Perspectives, COM(2007)161 final.

6 European Commission (2008a): Better Careers and More Mobility: A European Partnership For Researchers, Brussels, 23.5.2008, COM(2008)317 final, Communication from The Commission To The Council and the European Parliament.

7 Council of the European Union (2008) Presidency Conclusions – Brussels, 13/14 March 2008, p. 4-6.

8 *Ibid*.

The 2008 ERA Expert Group report[9] outlined, as dynamic goals, the four cornerstones upon which the policy options for the recruitment of researchers are to be formulated, namely, attraction, ethical recruitment and the retention of researchers; mobility in all its facets; researcher-friendly social security and supplementary pension systems; and the European Charter for Researchers and the Code of Conduct for their recruitment.

Such shared principles have been put forward across the EU. As expressed in the Green Paper on realising a single labour market for researchers, the EC Recommendation on a 'European Charter for Researchers and the Code of Conduct for their Recruitment' (C&C) "emerged from a bottom-up, Europe-wide consultative process. It sets out the rights and responsibilities of researchers, employers and funding agencies and encapsulates best practices drawn from across European policies and interests as understood by a wide range of organisations, including universities, businesses, public and private research bodies, associations and government agencies. Over 200 organisations, representing around 800 institutions in 23 countries have signed up to the C&C".[10]

The Annual Report on Research and Technological Development Activities of the European Union in 2010 placed the mobility issue at the heart of the future of ERA.[11] It stated that the mobility of researchers in Europe should be given priority and called for a strengthening of measures (such as pension portability and social security provisions, mutual recognition of professional qualifications, measures to reconcile family and work life, and research vouchers following researchers moving to another Member State) that will contribute to the mobility of European researchers, help stem the 'brain drain' and make the prospect of a research career in the EU more attractive. Furthermore it called on the Commission and the Member States to step up their effort to facilitate rapid mutual recognition of academic curricula.

In addition to the policy developments described above to address the framework conditions relating to the attractiveness of the research profession, attention was also given to measures that aim to support the integration and further development of researchers in European universities, research centres and industrial organisations. In addition, the 'Marie Curie Actions' were initiated under the Sixth Framework Programme for Research and Technological Development (FP6) in order to facilitate the long-term integration of researchers in the European research landscape and to support their scientific careers. These measures were rearticulated and reinforced in the 'people-specific' Programme of the Seventh Research Framework Programme (FP7). Entirely dedicated to human resources in research, this programme has a significant overall budget of more than EUR 4.7 billion over a seven year period up to 2013, which represents a 50% average annual increase over FP6.[12]

[9] European Commission (2008b): Realising a single labour market for researchers, Report of the ERA Expert Group, Directorate-General for Research EUR 23321 EN. Available at: http://ec.europa.eu/euraxess/pdf/research_policies/era_green_paper_eg1_lowres.pdf.

[10] European Commission (2008b), p. 18.

[11] European Commission (2011a): REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL: Annual Report on Research and Technological Development Activities of the European Union in 2010.

[12] European Commission (2010): Europe 2020 Flagship Initiative Innovation Union, Brussels, 6.10.2010, COM(2010) 546 final, Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee of the Regions, SEC(2010) 1161, p. 9.

A further measure with a clear focus on rewarding and supporting scientific excellence in all fields of research was the establishment of the European Research Council (ERC).[13] The ERC supports emerging research leaders through 'ERC Starting Grants' and established researchers that have already made leading contributions in a scientific field through 'ERC Advanced Grants'.

The overall ERC budget earmarked under FP7 was EUR 7.5 billion for the period 2007–2013, with a clear objective here being to leverage European Scientific competitiveness, by creating favourable conditions for new scientific and technological breakthroughs with an impact at an international scale.

A systematic examination of mobility and attractiveness issues in relation to the research profession in the EU was undertaken in the MORE study (Study on mobility patterns and career paths of EU researchers)[14] which analysed the issues involved, their various facets and their underlying dynamics. The MORE surveys addressed researcher populations in European Universities, Research Centres and Industry providing valuable information on their perceptions with regard to their profession and place of work. In this respect, the MORE study provides direct feedback on the policy areas that still need to be addressed.

Attractiveness is a very complex issue and perceptions differ greatly depending on factors such as the country of origin or disciplinary field. But an important conclusion of the MORE study was nevertheless that *"there is need to promote the attractiveness of EU countries as an environment to do research after having first understood the reasons why the EU is not perceived as the most attractive environment for research and having taken into account the significant differences among the EU Member States' needs"*.[15] At the same time it emerges from the MORE survey that most researchers tend to agree with the propositions that the USA is a better reference for a career as a researcher, that it also offers better opportunities to collaborate with top-class researchers and better funding opportunities than the EU. EU-researchers who have moved to the USA overwhelmingly confirm these points.

The European Research Area is one of the main instruments used to address the challenges involved in maintaining and developing a sufficiently large and competitive research force in Europe. The Commission's 2011 Green Paper, moreover, identified a specific challenge; "*Europe's science base is among the most productive in the world, yet it does not contain sufficient pockets of world class excellence where ground-breaking research results are generated which are able to drive structural change. In the long term, world class excellence can only thrive in a system in which all researchers across the EU are provided with the means to develop into excellence and eventually compete for the top spots. This requires Member States to pursue ambitious modernisation agendas for their public research base and sustain public funding. EU funding, also through the Cohesion policy Funds, should assist in building excellence as and where appropriate*".[16]

[13] ERC is the European Union funding body that implements the specific programme 'Ideas' under the 7th Research Framework Programme of the European Commission: http://erc.europa.eu/about-erc/facts-and-figures.

[14] IDEA Consult in consortium with NIFU STEP, WIFO, LOGOTECH and The University of Manchester, with the subcontractors Management Center Innsbruck (MCI) and MRB Hellas (2010): Study on mobility patterns and career paths of EU researchers.
Report available at: http://ec.europa.eu/euraxess/pdf/research_policies/MORE_final_report_final_version.pdf.

[15] Ibid, p. 149.

[16] European Commission (2011b) : GREEN PAPER, From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation funding, COM(2011) 48, p. 11.

Much however remains to be done while further concerted efforts and a common strategic position have recently been called for. One example here is the Innovation Union Competitiveness Report (2011)[17], where the issue of the EU's attractiveness to researchers was also raised. One aspect of this is the quality of education and the need to raise the level of ambition by focusing on excellence rather than universality, hence the focus on "top" research performers. The report, for instance, acknowledges that with a total of 111,000 awarded every year, the EU produces nearly twice as many as the United States.

This proportion is even higher for Science and Engineering where the EU produces more than twice the number of doctorates as the United States. However, relative to GDP, the United States invests about 2.5 times more in higher education than the EU, mainly due to much lower private spending in the EU. As a result, education expenditure per graduate or PhD student in the USA is considerably higher than in Europe, showing a stronger focus on quality than on quantity[18], which will be shown in our study to be also reflected in the quality and worldwide impact of the research produced.[19]

1.2. Scope of the work – key definitions

1.2.1. Relation to current policy challenges

The present study was conducted in the context of the ongoing preparation of "Horizon 2020"[20] and the expected Communication on "Enhancing and focusing international cooperation in Research and innovation".[21] These documents will address current and future challenges in relation to European research and, in particular, the issues involved in consolidating and expanding the European science and research base.

Our background analysis (section 1.1 above) indicates that the European science base is one of the most productive in the world, with progress undoubtedly also being made in relation to policies designed to improve the framework conditions for the research profession across the EU, specifically addressing attractiveness issues. Nevertheless, key challenges remain, one of which is to streamline efforts in response to the worldwide competition for scientific excellence.

As noted previously, the Innovation Union Competitiveness Report (2011)[22] calls for an increased focus on "top" research performers as a means to enhance European excellence in research. "Top research performer" is a notion that is closely related to top scientists. While the approach to defining 'top scientists' is further elaborated upon below[23], it is important at this stage to underline their 'driver effect' in relation to worldwide scientific excellence and competitiveness.

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[17] European Commission Directorate-General for Research and Innovation Directorate C — Research and Innovation (2011): Innovation Union Competitiveness Report.

[18] Ibid, p. 5.

[19] Please refer to section 2.1.

[20] Horizon 2020 is the new EU financing instrument combining all research and innovation funding currently provided through the Framework Programmes for Research and Technical Development, the innovation related activities of the Competitiveness and Innovation Framework Programme (CIP) and the European Institute of Innovation and Technology (EIT); The preparation of Horizon 2020 is a process involving an interaction among the key governance institutions of the EU. At the current time of writing the European Parliament is in the process of examining the Commission's proposal. The Commission's proposal is a package of legislative and non-legislative documents that can be found under: http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020-documents

[21] As per the Commission 2012 Work Programme. The Communication will set-out detailed objectives, criteria and operational principles for implementing, enhancing and focusing EU international cooperation actions under the Community Support Framework (CSF) for Research and Innovation.

[22] EUROPEAN COMMISSION Directorate-General for Research and Innovation Directorate C — Research and Innovation (2011): Innovation Union Competitiveness Report.

[23] Please refer to section 1.2.3 below.

As indicated in the MORE study discussed above, through their work, top scientists not only influence the advancement of science, but, more crucially, they help create favourable conditions for the emergence and development of competitive research environments around them: the outstanding performance of top researchers will in turn attract talented young researchers with strong motivations to distinguish themselves.

The greater the reputation of top scientists, the larger and more competitive will be the research group around them, leading to stronger positive effects on research quality and productivity.

Top scientists can, therefore, be viewed as important drivers in (1) advancing science and underpinning innovation, (2) creating around them critical masses of scientific activity and (3) attracting and sustaining further investments in research by public and private entities.

Attracting and supporting top scientists is, therefore, an important component for policy making at the EU and Member State level in the effort to address the challenges associated with maintaining and further developing the strength and competitiveness at a global scale of European research.

Competitive research communities/groups require a considerable amount of time to develop. As such, policies aiming to facilitate scientists in their desire to become world leaders in their fields, in turn, producing the self-perpetuating 'virtuous patterns' outlined above in relation to European universities and research centres, necessarily require considerable time and investment with their positive effects generally being felt on a longer timescale. Addressing the current problem of the need to improve the worldwide competitiveness of European research is however somewhat more urgent and shorter term positive effects could be triggered by improving the attractiveness of Europe for the actual top performers. It is therefore important to better understand the reasons why top scientists locate and/or relocate in the first place in order to develop policies that would make the EU and its Member States more attractive to top researchers.

1.2.2. Study objectives

The main research question of the study is: "Compared to selected competitors, in both a range of emerging economics and in those with the most dynamic research environments (e.g. the USA, China and Switzerland), how attractive is the EU for top international scientists and how can the EU and its Member States improve their performance in this area?" The study objective is, therefore, to:

- determine the main factors that influence the location/re-location choices of top scientists pertaining to their work environment;
- identify the current advantages and weaknesses of Europe with respect to other competing employment destinations around the world;
- propose a policy framework which will help enhance the attractiveness of the EU as an employment destination for top scientists.

1.2.3. Defining top scientists

One of the difficulties of the study is the notion of the object itself, namely, "*top scientists*", for which no universally accepted definition is currently available.

Definitions of key concepts can only rely on proxies, such as the definition of scientists (subsequently further qualified as ***top scientists***). The Canberra Manual[24] proposes a definition of Human Resources in Science and Technology (HRST) as *persons who either have higher, third level education or persons who are employed in positions that normally require such education.* The Frascati Manual defines *researchers* as *professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.*[25] Both terms are used for different purposes in surveys conducted by the OECD and Eurostat.

A scientist is "*a person who is studying or has expert knowledge of one or more of the natural or physical sciences*".[26] A scientist can be considered as a sub-set of HRST in the sense that s/he is employed in a position requiring higher education in science and/or technology. A scientist can also be considered as a sub-set of the population of researchers as defined above, since s/he is engaged in the activity to acquire knowledge. The differentiating factor would be in the higher level of "expert" knowledge that a scientist would have with respect to a researcher. There are, however, no universally accepted criteria enabling us to distinguish between "levels of knowledge and expertise".

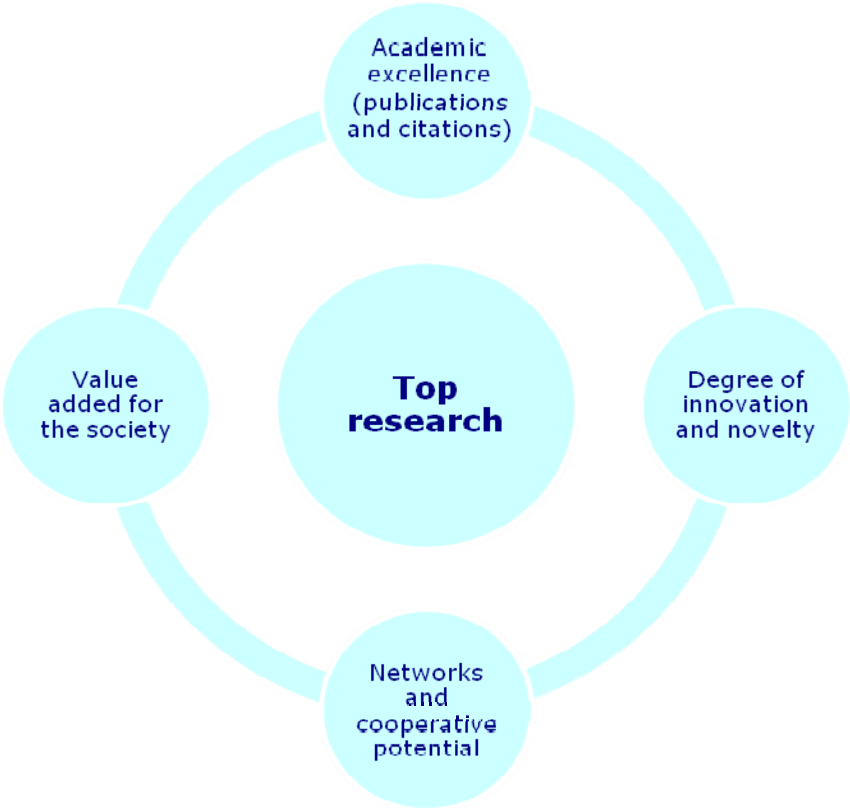
The notion of a 'top' scientist is, moreover, a less clear-cut and less widely used concept. In this study, we operationalise this notion with the characteristic elements of academic and scientific excellence forming the core of the concept, but also taking into account other criteria such as the influence that they might exert in their environment. The elements of 'top scientist' we will use are, therefore:

- Academic excellence and research production (main indicators: publications and citations);
- Leading members of Scientific Networks as a measure of cooperation with and influence on top research units;
- Value added for society, in terms of the relevance of their research topics to broader socio-economic challenges at the European and global levels;
- Degree of novelty of the scientific work produced.

These elements are illustrated in Figure 1 overleaf.

[24] OECD 1995. P. 16.
[25] OECD 2002. p. 93.
[26] http://oxforddictionaries.com/definition/scientist?q=scientist.

Figure 1: Characteristics of 'top research'



Source: Own illustration

1.2.4. Defining attractiveness - Attractiveness factors

For the purposes of our study, the *"attractiveness"* of a research area (either the ERA as a whole or particular Member States) is defined as the ability to be the work place of preference for top scientists who work either abroad (high level and persistence of inward mobility) or in the area (low level or regression of outward mobility).

In addressing the issues impacting attractiveness, we need to distinguish different factors that may have an influence. Such factors can be either personal or institutional in nature, i.e. can relate to motivational factors affecting the individual in question and his or her working and career conditions (issues relating to the wage level, remuneration, career prospects) or factors that relate to the institutional arrangements in place in the country in question (such as administrative or regulatory characteristics relating to researchers' working conditions).

Distinguishing such factors and measuring their effect is significant for the policy maker, as it enables them to develop targeted measures to address specific factors at the individual, local, national or European level.

Such factors, which we will term "*Attractiveness Factors*" (AFs), have already been examined in the framework of previous mobility studies, like MORE, referred to above. The survey, for instance, shed light on the reasons for and characteristics behind mobility, including[27]:

- Access to the facilities / equipment necessary for the research;
- Availability of suitable research collaborators;
- Industry linkages and links with companies and users of research;
- General availability and level of research funding at the national level;
- Ability to access funding for one's own research;
- Availability of career opportunities;
- Salary and incentives;
- Working conditions;
- Pension and social care provision;
- Attractive labour regulations (e.g. working week, health and safety laws);
- Immigration regulations.

Other previous studies have identified factors that induce mobility and, in this regard, one can seek to identify examples of policies, measures and practices which have a positive impact on these. Such factors identified have included[28]:

- Narrow local and national labour markets for specialised research workforce;
- Differences in salaries and funding opportunities;
- Possibilities to gain status more easily;
- Better subsequent job opportunities within or outside academia in some countries;
- Research activity and research infrastructure that better support research interests and career prospects;
- Quality of the research environment (people and facilities);
- Reputation of the host institution (e.g. international ranking);
- More attractive Graduate Programmes (PhD's) and professional training;
- Opportunities for researchers at the postdoctoral stage.

There are also a number of rather more general factors that impact on mobility, such as administrative obstacles (recruitment practices, visa policies etc.), as well as cultural and linguistic factors (e.g. familiarity of language, cultural skills).

[27] MORE Report – see footnote 10, p. 170-171.

[28] European Parliament (2009), Cross-border mobility of young researchers, Briefing note, Directorate General For Internal Policies, Policy Department A: Economic And Scientific Policy Industry, Research And Energy, p. 12

The attractiveness factors can be defined in two main groups: the positive incentives and motivational factors ("pull") and negative, restrictive factors ("push"). In previous studies, the positive motivational factors identified have included issues mainly relating to substantive research-related issues such as future career development, interesting research theme, participation in a collaborative research project and reputation of the host institution. Negative ("push") factors have for instance included complex administration procedures relating to relocation, a lack of support from the home institution (e.g. fear of losing current position), duties at the home institution and the lack of available research job opportunities abroad/fellowships for the stay abroad. Cultural and linguistic barriers are also mentioned, though in most studies they play a considerably less important role than the substantive issues referred to above.[29]

In the absence of related studies on top scientists, our main working assumption was that most of the issues influencing career choices and mobility decisions for other scientists/researchers also apply to top scientists. Our hypothesis is therefore that top scientists choose their place of work in a similar way to other scientists/researchers, while perhaps having more choices open to them. If anything, top scientists are more demanding in their location choices and thus what applies to other researchers can basically be expected to be further accentuated in the case of internationally competitive top scientists.

For the purposes of our study we have selected from the attractiveness factors of previous studies the ones that may be more relevant to the status and aspirations of top scientists and grouped them into the following broad categories:

1) **Institutional factors relating to the research environment:** Quality of the research environment (people, facilities and resources) and institutional reputation of the host institution (e.g. international ranking); Availability of suitable research collaborators (including innovation ecosystem, social capital and network capacity);
2) **Institutional factors relating to funding**: General availability and level of research funding nationally; Ability to access funding for one's own research;
3) **Personal factors**, such as personal incentives and remuneration: Salary and incentives; Working conditions; Pension and social care provision; Attractive labour regulations (e.g. working week, health and safety laws);
4) **Quality of life factors**: e.g. Climate, Safety /security (low crime rate), quality of public services (healthcare, childcare);
5) **Other factors**: issues that impact on mobility, in most cases bottlenecks or hindrances, such as administrative obstacles (recruitment practices, visa policies, immigration regulations etc.), as well as cultural and linguistic factors (e.g. familiarity of language, cultural skills).

These factors are significant in influencing the outflow and inflow of researchers and top researchers in particular. Here, another concept is often used, namely that of '*brain drain*'.

According to the Merriam-Webster dictionary, '*brain drain*' refers to the "departure of educated or professional people from one country, economic sector, or field for another usually for better pay or living conditions".[30] Our interest is not however on the brain drain phenomenon in general but rather on the brain drain of top researchers.

[29] Ivancheva & Gourova (2012) : Challenges for career and mobility of researchers in Europe, Forthcoming, Science and Public Policy, p.15.

[30] Merriam-Webster Online dictionary.

1.2.5. Selecting Member States and Competing Countries

While the EU as a whole is our unit of analysis we have selected a number of Member States and third countries to focus on. Their selection was intended to provide a sufficiently representative sample of both high and low performers (in terms of innovation and R&D more broadly), as well as to allow for variation in the third country selection.

The countries chosen (Table 1 below) include the EU Member States of Bulgaria, Estonia, Finland, Germany, Greece, Italy and Portugal with, in addition, Switzerland providing an interesting case of attractive research mobility and the USA and the BRIC countries representing the third country variation.

Table 1: Countries selected for the Policy Framework Analysis

EU Member States	Competing Countries
• 2 "Northern" countries: Germany and Finland • 3 "Southern" countries: Italy, Portugal and Greece • 2 new Member States: Estonia and Bulgaria	• Brazil • China • India • Russia • Switzerland • United States

1.3. Methodology

1.3.1. Methodological approach to the study

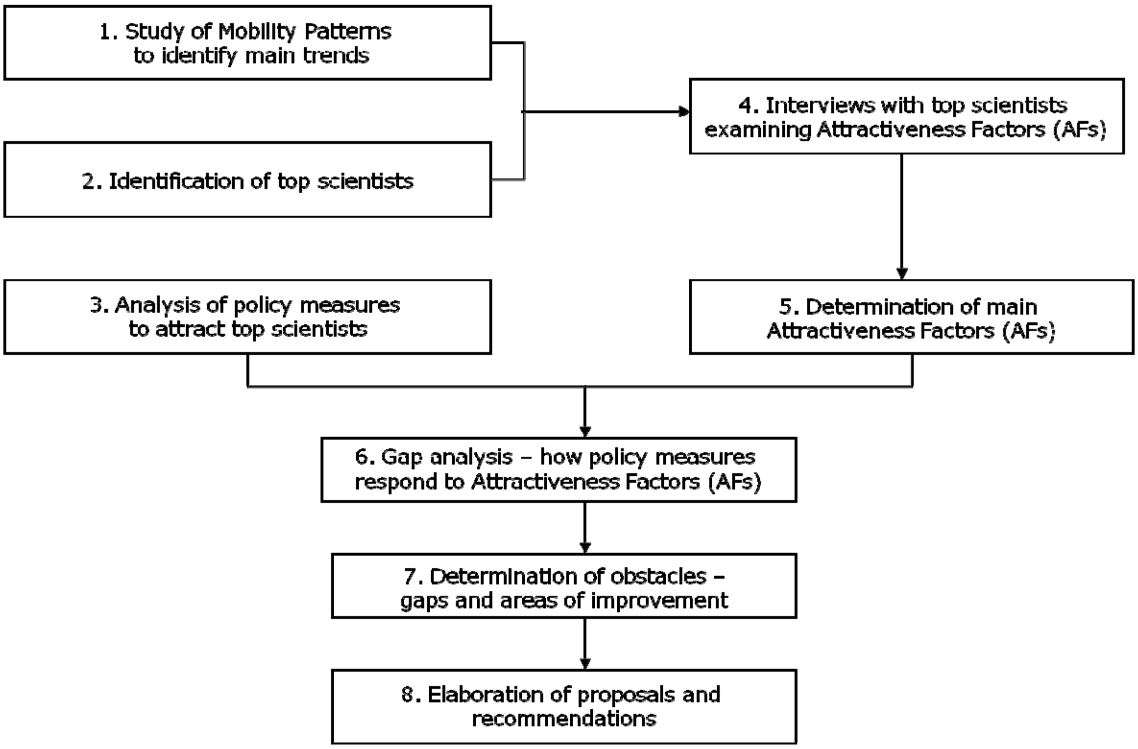
The study relies in the main on second hand sources. The focus is on top scientists, for which, as mentioned above, there is currently no universally accepted definition and, therefore, no systematic studies of their patterns of mobility.

The starting point is the identification of the main trends in terms of researcher mobility, with our main working assumption being that what generally applies in terms of the mobility and attractiveness of specific research environments and countries in the eyes of researchers also applies to 'top' scientists.

The main steps of our methodological approach are presented below (their interrelations are illustrated in Figure 2):

1) determine trends of relevance from mobility studies: motivations, reasons for, reasons against and associated statistics – first list of Attractiveness Factors (AFs);
2) identify top scientists for further interviews;
3) examine how current policies at EU/MS level address the issue of attracting top scientists;
4) conduct a number of interviews with identified top scientists that will confirm/extend and contextualise the AFs;
5) determine main AFs;
6) compare AFs to policy measures: gap analysis;
7) identify obstacles – gaps and areas in need of improvement;
8) propose solutions and recommendations that address the AFs.

Figure 2: Conceptual methodological diagram



Source: Authors

As our study has focused on the distinct patterns of retaining European talent (and in some cases increasing mobility within Europe), supporting the return of European nationals from abroad, as well as (in particular) of attracting non-Europeans to Europe, the interviews with top researchers (16 in total) also sought to address all of these relevant groups.

In the sample of interviews, we included:

- Europeans working[31] in Europe;
- Europeans working abroad;
- non-Europeans working in Europe;
- non-Europeans working abroad.

The criteria for selecting the interviewees were based on the distinctive features used for top scientists in our analysis (chapter 1.2.3). An equally important feature for the selection was also direct experience with at least two regions/countries, preferably among the ones targeted in our study, so as to have opinions based on own experiences.

Most EU interviewees have shared their research career in two different research environments, most frequently these being an EU country and the USA in the framework of long-term mobility (several months, years of continuous work in either country). Most of the interviewees have an international career, involving collaborations with scientists around the world and including short term stays (several stays of a few weeks each) in other countries.

1.3.2. Discussion of the research method used and its imitations

An important task of the method chosen consisted in identifying the most relevant attractiveness factors in order to formulate working hypothesis which can be universally valid, yet still pertinent. Attractiveness factors thus encapsulate the core elements of what constitutes the motivational fabric researcher mobility. We have identified from previous research a number of factors that seem to play a role in determining the choice of individual research venues. These are analysed in greater detail in chapter 2, as well as in the conclusions.

It was also challenging to compile a sample of interview cases, considering that the factors influencing individual choices of location and career are much more complex than any one combination of parameters and factors could ever reflect.

The policy measures and instruments available mostly relate to developing research infrastructure and environments of high standard, as well as, in some cases, of identifying and addressing the needs of specific target groups (such as expatriate researchers, potential recruits etc). We sought to identify policy instruments that address the different types of attractiveness factors included in the study, though it is often difficult to get the full picture of the effectiveness or success rate of these instruments.

The path dependent and invariably slow nature of promoting the attractiveness of specific research environments for top scientists is an important aspect to bear in mind when policy measures and instruments are considered. This is particularly the case in light of the long-term nature of creating attractive research environments: the choices an individual researcher makes may be the outcome of a long personal process (of getting acquainted with fellow researchers from various countries), deeply rooted in social networking (of perhaps one individual researcher creating ties that may later, perhaps 2-5 student generations later) lead to more institutional contacts.

[31] "Working" is used here in the sense of a long term position, because the aim is to examine the reasons for choosing a particular country/area for a long-term professional career.

The definitions that the study works with and seeks to operationalise were also challenging, as no single standardised definition of top scientist currently exists. Another challenge concerned the unit of analysis: while in mobility studies the unit of analysis is an individual researcher, in our study the unit of analysis is to a large extent the Member State and its specific research environment, with all the actors that this entails (in particular the Higher Education Institutions, research funding bodies and the government). As our key task was to produce analytical evidence on the attractiveness factors behind the mobility choices of top scientists, the crucial definitions and concepts for this study were: "attractiveness" and "top scientists", both of which are, for instance, more arbitrary in nature than those of 'researchers' and 'mobility' used in the MORE study.

As argued in the MORE study, there is no single accepted definition of international mobility while the notion of researcher mobility is more problematic than other forms of mobility in relation to highly-skilled labour as it is does not necessarily involve migration or a trans-national work status. 'Researcher mobility' often involves shorter visits and exchanges to research institutions, collaborators or facilities elsewhere.[32]

This also renders the attractiveness of research environments problematic as an object of study, as it is often the case that the researchers that visit other environments for the purposes of pursuing their research are often motivated by a variety of issues, most notably personal and institutional contacts and previous experiences of researcher mobility. Therefore, the push and pull factors here are less determined by the attractiveness of the research venue itself than by a more complex process of long path dependence.

1.4. Structure of the study

This report is structured as follows: The introduction covers the background, scope and objectives, key definitions, as well as the method used and its limitations.

The second chapter presents an overview of the mobility patterns and the main reasons – attractiveness factors - that push top scientists to select their places of work. The documentary material on the general topic of mobility, which is mainly based on second hand sources, such as reports and analysis around the studies on mobility patterns and career paths for top or star scientists, is however quite limited. There are also some very limited statistical data available, which we have collected and analysed, mostly compiled in order to provide a contextual background to the study. This chapter also includes the interview materials, based on the small sample of interviews undertaken during the course of the study among EU and non-EU researchers in order to shed further light on the issue of 'attractiveness factors' and their relevance for top scientists.

The third chapter provides an overview of related policies and measures at the EU level and also at the level of the selected EU Member States and competing countries. This chapter relies largely on the materials compiled for the ERAWATCH reports[33], both in the form of analytical reports and case descriptions on policies. The focus here is on the policy context,

[32] MORE 2011, technical report, p. 5.

[33] The ERA-NET scheme was established with the intention of coordinating the cooperation and research activities carried out at the national or regional levels in the member states and associated states through the networking of research activities conducted at the national or regional level, and the mutual opening of national and regional research programmes. ERAWATCH is a joint initiative of the European Commission's Directorate General for Research and Innovation and Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS). The activities undertaken include the country reports, analytical reports and various thematic reports, which are produced under contract, by the ERAWATCH Network formed by national experts in research and innovation policies. The analytical framework and the structure of the reports have been developed by the Institute for Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) with contributions from Directorate General for Research and Innovation and the ERAWATCH Network.

the national strategies and the instruments employed in order to address the attractiveness of national research environments for top scientists. In some cases, these sources have been complemented by contacts and additional information provided by the ERAWATCH experts[34] and other national contacts. This material is analysed and summarised primarily in chapter 3 with the policy analysis, consisting of country descriptions, categorisation and brief description of the policy instruments and the identification of possible gaps.

Chapter 4 discusses how the policy framework examined in chapter 3 responds to the attractiveness factors discussed in chapter 2, in order to identify the strengths and weaknesses or obstacles faced.

Conclusions and policy recommendations are summarised in chapter 5, based on the previous chapters. Conclusions are drawn, for both the EU and the individual Member States, on the level of attractiveness factors and their centrality, as well as with regard to the national strategies and policy instruments implemented in order to promote them.

[34] See previous footnote on the network of experts. The reports and other materials are available in electronic form at: the ERAWATCH website (http://erawatch.jrc.ec.europa.eu/).

2. ATTRACTIVENESS FACTORS FOR TOP SCIENTISTS

This section of the study focuses on the factors that top scientists primarily consider when selecting their place of work. The analysis begins with an overview of the available literature on mobility patterns for top scientists (section 2.1). As shown, available studies enable us only to identify some very basic trends in terms of mobility patterns, while no systematic investigation has hitherto been undertaken on the reasons that push top scientists to stay in their current professional environment or to relocate.

A key aspect of our methodology (section 1.3.1) was to develop a typology for the attractiveness factors that would be relevant for top scientists (section 1.2.4) and then, confirm/extend and contextualise them through interviews with selected top scientists. Following this approach, we have grouped the main findings of these interviews into section 2.2 and organised the presentation along the main categories considered for the attractiveness factors. The main conclusions in respect of the reasons why top scientists select their working environment are presented in section 2.3.

2.1. Recent studies on the mobility of top researchers

Empirical evidence about the spatial movements of elite scientists remains scarce.[35] Their migration process has often been regarded as part of the overall problem of brain drain, but methods that focus upon general tendencies have failed to delineate the patterns of migration among specific groups.[36]

Since the migration patterns of top scientists as a specific group have not been consistently tracked in the large mobility studies, a complete picture of the inflow of top international scientists to the EU or their outflow to third countries is not currently available. Through our literature review, we identified studies that provide useful quantitative information on certain categories of top scientists, while others examine researcher mobility in more general terms. The key related observations are presented below.

Maier *et al*.[37] analysed the international mobility of top researchers by concentrating on the Institute for Systems and Innovation (ISI) highly cited scientists over various disciplines and found a high concentration of scholars in Western countries, especially in the USA. This is also the case with young researchers. A study undertaken by IISER[38] found that the intra-EU mobility of doctoral candidates is comparatively low (5.5% of the total). At the same time, there is considerable mobility from the EU to the USA (2.4% of all doctorates from American universities are granted to Europeans).

In the study by Laudel[39] on mobility patterns from the American perspective, it was noted that the mobility of top scientists works in the main to the advantage of the USA. According to the study, the USA has both a significant proportion of scientific elites and a comparatively 'rich' science system. However, an interesting finding in the study was that migration to the USA appeared to occur less often when scientists were already members

[35] Trippl, M. 2011. Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial Concentration and Mobility Patterns. Regional Studies. DOI:10.1080/00343404.2011.556613. See also Laudel, 2005; Hunter *et al*., 2009.

[36] Laudel, G. 2005. Migration currents among the scientific elite. Minerva, vol.43, no.4, pp.377-395.

[37] Maier, G., Kurka,B.,; Trippl, M. 2007. Knowledge spillover agents and regional development - spatial distribution and mobility of star scientists, DYNREG Working Paper 17/2007.

[38] The Integrated Information System on European Researchers project.

[39] Laudel, G. 2005. Migration currents among the scientific elite. Minerva, vol.43, no.4, pp.377-395.

of the scientific elite. Moreover, a study by Tritah[40] found that the flow of human capital through European migrants to the USA has increased in recent decades.

The brain drain also seems to differ between countries. In particular, countries without a critical mass of top researchers are more likely to lose their top researchers to other countries, specifically to the USA[41]. It has also been noted that it is usually not the established top scientists that move, but the young talented researchers, i.e. the potential elite.

A rather more comprehensive mapping of top scientists and their spatial mobility patterns has been undertaken based on highly-cited researchers.[42] The major finding of this study is that the spatial distribution and mobility patterns of top scientists are highly uneven. The USA dominates as a destination for top scientists as two-thirds of all highly-cited researchers in the study sample were located in the USA. The share of Western European countries was just 22.5%. A comparison of places of birth and residence shows that migration flows of top scientists go mainly towards the USA. The migration balance of all other countries is negative except for France and Switzerland. As stated by Schiller *et al*. "*The positive inflows increase the number of top scientists in the US by 50% while Western European countries are losing a third of their top scientists. Also the mobility between Western European countries is much lower than between Western Europe (without UK) and the US. Only 13% of the star scientists in Western Europe are born in another Western European country".*[43]

[40] Tritah, A. 2008. The Brain Drain between Knowledge-Based Economies: the European Human Capital Outflow to the US. CEPII working paper.

[41] Ioannidis, J. 2004. Global estimates of high-level brain drain and deficit, Journal of the Federation of American Societies for Experimental Biology, vol.18, pp. 936-939.

[42] Maier *et al*. 2007; see also Schiller *et al*., 2008.

[43] Schiller, D. and Revilla Diez, J. 2008. Leibniz Mobile star scientists as regional knowledge spillover agents. University of Hannover, Germany 11/2008. IAREG Working Paper WP2/7, p. 17;Maier, G., B. Kurka, and M. Trippl 2007. Knowledge spillover agents and regional development – spatial distribution and mobility of star scientists. DYNREG Working Paper 17/2007. Vienna, p. 19.

Table 2: Star scientists by place of birth and place of residence

Country	Number of star scientists by place of residence	Number of star scientists by place of birth	Share of star scientists by place of residence	Share of star scientists by place of birth	Balance[2]
USA	3,620	973	66.2%	42.7%	23.4%
Western Europe	1,232	755	22.5%	33.1%	-10.6%
UK	418	255	7.6%	11.2%	-3.6%
Germany	228	135	4.2%	5.9%	-1.8%
France	146	49	2.7%	2.2%	0.5%
Switzerland	99	40	1.8%	1.8%	0.1%
Netherlands	90	56	1.6%	2.5%	-0.8%
Italy	70	66	1.3%	2.9%	-1.6%
Sweden	55	34	1.0%	1.5%	-0.5%
Belgium	33	27	0.6%	1.2%	-0.6%
Denmark	28	14	0.5%	0.6%	-0.1%
Spain	18	13	0.3%	0.6%	-0.2%
Finland	13	13	0.2%	0.6%	-0.3%
Austria	12	20	0.2%	0.9%	-0.7%
Norway	10	9	0.2%	0.4%	-0.2%
Ireland	7	9	0.1%	0.4%	-0.3%
Greece	4	8	0.1%	0.4%	-0.3%
Portugal	1	4	0.0%	0.2%	-0.2%
Luxembourg	0	2	0.0%	0.1%	-0.1%
Cyprus	0	1	0.0%	0.0%	0.0%
Japan	218	104	4.0%	4.6%	-0.6%
Canada	162	68	3.0%	3.0%	0.0%
Oceania	117	87	2.1%	3.8%	-1.7%
Israel	47	29	0.9%	1.3%	-0.4%
China	19	42	0.3%	1.8%	-1.5%
Asia (w/o China and India)	17	25	0.3%	1.1%	-0.8%
India	11	40	0.2%	1.8%	-1.6%
Central & Eastern Europe	8	71	0.1%	3.1%	-3.0%
Latin America	8	38	0.1%	1.7%	-1.5%
South Africa	6	11	0.1%	0.5%	-0.4%
Russia	4	11	0.1%	0.5%	-0.4%
Middle East	2	13	0.0%	0.6%	-0.5%
Africa	1	11	0.0%	0.5%	-0.5%
Total	5,472	2,278	100.0%	100.0%	0.0%
Missing values	98	3,292			

[1] Information about the place of birth is voluntarily provided by the star scientists themselves
[2] The difference of shares by place of residence and place of birth

Source: Compilation by Schiller *et al.* 2008 based on Maier *et al*. 2007.

Another recent study on the migration process was carried by Zucker and Darby[44] where they followed the careers between years 1981 and 2004 of 5401 'star scientists' listed in ISI HighlyCitedSM[45] as most highly cited by their peers. They argue that given the right institutional conditions, a significant fraction of star scientists also become *star innovators* "*who drive growth and progress via creating and transforming high-technology industries, usually while continuing to make major contributions to science*".[46]

Table 3: Migration of top researchers

	Professional Net Inward Net Unique Debuts[b]	Outward Migration		Inward Migration		Net Inward Migration[e]	Net Stock[f]	Unique Persons[g]
		One-way[c]	Round-trip[d]	One-way[c]	Round-trip[d]			
OECD member countries Europe								
Austria	14	6	1	2	20	-4	10	36
Belgium	37	7	1	2	15	-5	32	54
Denmark	29	5	3	5	15	0	29	49
Finland	14	2	1	0	7	-2	12	20
France	135	20	19	22	114	2	137	265
Germany	222	35	17	24	123	-11	211	362
Italy	60	14	11	16	47	2	62	120
Netherlands	78	10	4	8	30	-2	76	115
Norway	12	2	1	3	13	1	13	27
Poland	6	4	3	1	15	-3	3	22
Spain	13	1	1	8	29	7	20	49
Sweden	70	12	7	5	40	-7	63	112
Switzerland	80	17	7	27	45	10	90	148
United Kingdom	424	70	31	43	122	-27	397	581
Europe[a]	*1194*	*205*	*107*	*166*	*635*	*-39*	*1155*	*1960*
APEC member countries								
Australia	97	15	10	25	49	10	107	170
Canada	201	51	13	28	72	-23	178	300
Japan	176	5	15	18	76	13	189	266
South-Korea	1	0	0	4	7	4	5	12
Non-U.S. APEC [a]	*475*	*71*	*38*	*75*	*204*	*4*	*479*	*748*
United States	3354	142	276	119	216	-23	3331	3670
APEC Countries a	*3829*	*213*	*314*	*194*	*420*	*-19*	*3810*	*4418*
OECD Member Countries[a]	**5023**	**418**	**421**	**360**	**1055**	**-58**	**4965**	**6378**
OECD non-member countries								
Brazil	1	1	0	3	15	2	3	19
China	4	1	0	11	26	10	14	39
India	10	3	1	3	14	0	10	27
Israel	57	13	5	4	28	-9	48	86
Russia/USSR	7	4	0	4	27	0	7	36
Taiwan	3	1	0	5	6	4	7	14
OECD Non-member Countries[a]	**82**	**23**	**6**	**30**	**116**	**7**	**89**	**221**
Top-25 S&T Countries[a]	**5105**	**441**	**427**	**390**	**1171**	**-51**	**5054**	**6599**
Top-24 Non-U.S. S&T Countries[a]	**1751**	**299**	**151**	**271**	**955**	**-28**	**1723**	**2929**

Source: Zucker and Darby (2007; 2007b)

[44] Zucker L. and Darby M. 2007. Star Scientists, Innovation and Regional and National Immigration. Working Paper 13547. National Bureau of Economic Research. October 2007.

[45] http://researchanalytics.thomsonreuters.com/highlycited/ .

[46] Zucker and Darby, *op. cit*.

Notes:

a. Totals of individual country values have not been adjusted for double counting due to within-region migration.
b. Each person who publishes or patents giving an address in the country the first year that person publishes or patents anywhere is counted as making a professional debut in the country. It is possible for one star to make a professional debut in more than one country and in a country other than the country of his or her birth or citizenship.
c. One-way immigration refers to the person stopping publishing or patenting in a country where they had been doing so and starting doing that in another country with no subsequent return to the first country. "Visits" of 2 years or less do not count for inward or outward migration.
d. Round-trip immigration refers to the person stopping publishing or patenting in a country where they had been doing so and starting doing that in another country and subsequently returning to the first country. "Visits" of 2 years or less do not count for inward or outward migration.
e. Net inward migration is one-way inward migration minus one-way outward migration. Round-trip inward and outward migration leave the stock of stars unchanged.
f. The net stock of stars is the number making professional debuts in the country plus one-way inward migration minus one-way outward migration, with no adjustment for death or retirement due to lack of information on when that occurs.
g. Unique persons is a count of the number of stars who have ever published or patented with an address in the country.

Table 2[47] presents novel evidence on the location and migration of star scientists and engineers among the top-25 S&T countries. According to Zucker and Darby, "about 93 percent of the world's star scientists and engineers have residences in the top-25 S&T countries at the end of 2004 – 62 percent in the USA alone".[48] According to the study, there was evidence of a reversal of the traditional brain drain from other countries, particularly less developed ones, to the USA and other science powerhouses like Britain and Germany.

In a more recent study[49], it was observed that top scientists tend to often migrate to the so-called "islands of innovation" i.e. in a limited amount of locations that act as major centres in international brain circulation. However, clear differences were identified between the USA and the European islands of innovation. The top US centres were found to be highly successful in attracting expatriate talent and at the same time they seemed to lose few native-born stars. Compared with the USA, the European top centres perform less well specifically when it comes to *attracting foreign star scientists* but are highly successful in luring back returning scientists. This is an important finding since it may help to define the focus of policy initiatives aiming at attracting top researchers.

There are several attractiveness factors that affect the mobility of top researchers. According to a study by Bergman[50], typical conditions most highly sought by academics in top institutions are: better research opportunities, higher salaries and promotions. On the personal factors, it has also been observed that having a PhD from a top institution and being male significantly increases the probability of making at least one international move during a foreign researcher's career.[51]

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[47] Data based on: Zucker L. & Darby, M. 2007b. Science, Knowledge, and Firms in Developing Economies, paper presented at the Micro Evidence on Innovation in Developing Economies, MERIT, United Nations University, Maastricht, The Netherlands, 31 May - 1 June.

[48] Zucker and Darby, 2007, p. 16. It should be noted that methods to define top scientists that are based on ISI citation metrics are inherently biased in favour of English-speaking and particularly American scientists: for a non-English language publication to be ISI-listed, English translations of at least the title and abstract should be available. It would, therefore, be natural to assume that the exact figures may exaggerate the dominant position of the USA, since publications that are not written in English and for which there is no English translation of title and abstract are not taken into account.

[49] Trippl, M. 2011. Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial Concentration and Mobility Patterns. Regional Studies. DOI:10.1080/00343404.2011.556613.

[50] Bergman, E. 2011. "Hirschmann Mobility Among Academics of Highly Ranked EU Research Universities," ERSA conference papers ersa11p1134, European Regional Science Association.

[51] Van Bowel, L. 2010. International Mobility Patterns of Researchers and Their Determinants. Paper presented at the Druid Summer Conference 2010 on "Opening Up Innovation: Strategy, Organization and Technology" at Imperial College London Business School, 16 - 18 June 2010.

One of the main reasons for mobility and the relocation of researchers seems to be the difference in the wage levels for highly skilled researchers between Europe and the USA, with the latter offering considerably higher salaries than the former, and this difference has increased over time since 1990.

2.2. Findings from interviews with top scientists

2.2.1. Main factors in top scientists' choice of workplace

The majority of the top scientists in Europe and in third countries that have been interviewed[52] in the course of this study indicated that the main factors relating to their choice of work were those relating to the nature of the research environment and research funding. The other factors examined, such as those relating to personal, quality of life and other issues were considered in most cases to be either secondary or not important at all. The main related findings are presented below.

Research environment

For all interviewees, the nature of the research environment is a primary reason for their choice of work. A competitive research environment is characterised by the research level of the hosting department and the geographic proximity of other lead scientists, enabling fruitful exchanges on scientific topics.

For top scientists that have teaching duties, the educational level and quality of the under-graduate and graduate students in the courses to be taught is an equally important characteristic of the research environment. For others that work in fields of more applied research, the proximity of work and the institution's relations with leading high-tech industries may be a crucial element in their choice to relocate.

Another aspect put forward in the course of the interviewees is that of "continuity" in the CV of the scientist: some lead scientists attach significant importance to the reputation and prestige of their institution and would only move to equally well-known and prestigious institutions.

In general, the research environment in leading American universities is considered to be superior to that of the EU average. The interviewees consider that there are universities in the UK, Germany and Switzerland that can however offer similar conditions.

Research funding

While the level of funding needed may show significant variations from discipline to discipline, especially when theoretical fields are compared to those requiring heavy research infrastructures, access to the means to conduct high-level research is another very important factor. The flexibility of this funding is also viewed as important since it enables the top scientists to become much more engaged in 'cutting-edge' research.

Most of the scientists interviewed indicated that the research funding opportunities are stronger in the United States than in Europe, especially for exploratory research in the frontiers of science and thematic fields that are closely related to 'hot topics' for the industry concerned. Research funding is considered to be on a relatively equal footing with the USA in countries like Germany, Finland and in certain places in the UK. Top scientists working in Europe also view access to EU and regional funding as a significant additional asset.

[52] See 1.3.1 for methodology and Annex 1 for the list of interviews.

Personal factors

Remuneration is generally not such an important factor, but this often relates more to the fact that most interviewees already earn very competitive salaries in their current position and would consider it normal to be in position to negotiate similar salaries in their next place of work.

More generally, top scientists are able to negotiate their own salary and benefits in the United States, though this is the case in only a few countries and institutions in the EU. The salaries for top professors in the United States may range from 100 to 300,000 euro for the teaching term (9 months per year) plus benefits for housing and school education. As indicated by one interviewee, the "package" that an American university is willing to offer to a top scientist is only determined by its wish to hire this scientist and this depends on his/her scientific reputation and the impact of his/her work in science and business. The negotiation margins for European universities are much narrower with only a handful of universities in the UK, Switzerland and Germany able to offer comparable levels of remuneration.

These findings are supported by other studies. For example in the study by Bergman[53], academics in top institutions essentially look for the following: better research opportunities, higher salaries and promotions. As to the reasons for relocating, one of the primary factors seems to be the difference in the wages for highly skilled researchers between Europe and the USA. This difference has increased over time since 1990.

Other countries like China, Singapore and Saudi Arabia also offer competitive remuneration packages for top scientists for both short and long-term positions. Some of the interviewees mentioned such offers and would consider working, or have already worked, in these countries on a short-term basis.

More general observations

In the course of the interviews, a number of points were raised concerning some aspects that would need to be taken into account with regards to the environment of work:

- European universities are in general considered to have more rigid structures than American ones. Due to long teaching hours and administrative obligations, professors at most European universities have less time to spend on their research activities. The stricter obligations in terms of teaching hours, the heavier bureaucracy load involved and the more rigid hierarchical structures are all factors that may impede a top scientist from accepting an offer from a leading European university.
- In Europe, the tenure track issues have not been fully addressed. There are no clear career steps from PhD to full professorship and it is frequent for a large number of scientists to remain at an entry level to the profession, such as associate professor, for a very long time. Thus, on the most basic level, career development paths need to become much more clearly defined and structured for European universities to be able to compete on a more equal footing. At the same time, more opportunities for swift advancement should be given to promising researchers and scientists.
- Recruiting PhDs and postdoctoral researchers (postdocs) in most European universities is less straightforward than in American universities, due to the bureaucratic nature of the process, opaque selection criteria and the uncertain availability of funding. Such barriers potentially then exhibit a negative influence on

[53] Bergman, E. 2011. "Hirschmann Mobility Among Academics of Highly Ranked EU Research Universities," ERSA conference papers ersa11p1134, European Regional Science Association.

top scientists who see the ability to build a strong research team as an essential factor in their ability to successfully pursue their research activities.

- The mobility of European scientists may also be hampered by the implications of 'relocating' on career advancement and pension plans. Moving around in Europe and abroad as a scientist / researcher may imply that the work done under contracts with institutions in other countries is not accredited at the mother institute and is not taken into account as prior service for the salary calculation and for the years of actual service in relation to pension after retirement. In one interview, a leading European scientist who currently holds an important position in an American university indicated that the major reason for not returning to Europe is that his pension will be a very small fraction of his actual earnings, because the system does not allow him to take into consideration his years of work abroad.

2.2.2. Aspects relating to participation in EU framework Programmes

For top scientists working in Europe and those who have previously worked in the United States, the Commission's Framework Programmes are certainly viewed as an opportunity to attract funding for their research and to increase their cooperation networks at the EU level. While they acknowledge the need for reporting and other administrative requirements, they generally feel that the level of managerial overhead involved is too large and that this has the effect of taking precious time away from their ability to pursue their research activities. As one of the interviewees put it "*the fear and need to control so much is hard to understand from somebody who comes from the USA, for example*".

Top scientists who work outside Europe seem to have a limited knowledge of the way EU research funding is organised and would find it hard to identify areas where they could fit in to this process. In general, the funding level offered by the Framework Programmes represents a small fraction of research funding that a top American scientist can raise through other sources. The relatively paucity of funding expected, combined with the often onerous administrative requirements, are thus simply inadequate in the context of encouraging leading researchers from the other side of the Atlantic to participate in collaborative EU programmes. However, leading American scientists would seem more inclined to participate in:

- focused cooperation schemes, in areas where the EU has a strong reputation and a tradition of excellence. Examples of such areas would certainly include industrial fields where the EU has a leading position, but also other fields, related for example to social care and systems for the disabled and the elderly such as *e*-inclusion and *e*-health;
- schemes that are characterised by reduced bureaucracy and a more results-oriented evaluation of the outputs that might be based more on their scientific quality and less on the number of deliverables;
- research programmes enabling a bottom-up approach, like the one used in the Future and Emerging Technology (FET) schemes[54], rather than the top-down approach of most of the Work Programmes of FP7.

[54] Future and Emerging Technology (FET) are funding schemes under the Research Framework Programmes of the Commission that support exploratory research to open up new themes across the full breadth of future information and communication technologies (ICT). "FET aim to go beyond the conventional boundaries of ICT and venture into uncharted areas, often inspired by and in close collaboration with other scientific disciplines" - http://www.pro-ideal.eu/FET.

2.3. Main attractiveness factors for top scientists

The conclusions of the secondary literature search and the findings of the limited number of interviews presented above could be summarised as follows. Firstly, top scientists seem to be relatively mobile. Secondly, they are primarily attracted by stimulating research environments in research institutions that compete at a global level and which can also ensure better funding opportunities. Thirdly, salaries may play a role and in this respect, only a few European centres are in a position to match the remuneration packages and other benefits offered by leading American universities.

More specific conclusions with regard to the attractiveness factors identified in our methodological approach (section 1.2.4) are provided below:

1) **Institutional factors relating to the research environment:** the quality of the research environment is a key factor in the choice of the work environment an attractive research environment should combine:
   - ambition and talent of colleagues and young researchers;
   - high reputation of the hosting institution;
   - flexibility in the definition of research topics;
   - limited constraints with respect to teaching and administration obligations, enabling a strong focus on research activities.

2) **Institutional factors relating to funding**: this is also an important attractiveness factor, the main aspect being related to the possibility of obtaining funding for cutting-edge research, which includes the availability of funds and flexibility in hiring promising young scientists for PhD and postdoc positions.

3) **Personal factors**: remuneration is not considered to be a decisive factor by the interviewees, because most of them are already in a position to negotiate high salaries. If two employer organisations offer comparable salaries, the one that will be chosen is the one that offers better opportunities with regard to the research environment. The social care provision and the pension condition (when moving from one country to another) may also be factors to be considered.

4) **Quality of life factors**: such factors are not considered to play a significant role by the interviewees. They generally assume that the places that can offer an attractive research environment would most likely offer a corresponding high living environment.
   Other factors: administrative matters (recruitment practices, visa policies, immigration regulations etc.), as well as cultural and linguistic factors may play a role if they negatively affect the environment and the availability of research funding.

Geographically, the USA is still the dominant academic destination attracting top researchers from all over the world (including Europe). The USA is indeed an interesting and highly relevant benchmark for the EU. As noted at the end of section 1.1, a distinctive feature here is the focus on research 'quality versus quantity'. It cannot be stressed highly enough that this approach has a significant impact on quality and on the impact of the research produced.

A proxy frequently used to measure the quality of research papers is the number of citations a publication receives over a fixed period of time following its appearance as a measure of its relevance and utility for scientific progress.

Figures for the share of a world region or country in the total number of publications to its share in the 10% most cited publications are given in a report by the European Commission[55] for scientific papers produced in 2000 and 2003 with citation windows respectively for 2000 to 2003 and 2003 to 2006. A ratio above 1 indicates that the world region/country contributes more to the 10% most cited publications than expected, given its total publication output. The share of United States in the world's 10% most cited publications is about 1.5 times higher than its share in total world publications. In contrast, the EU share in the world's 10% most cited publications is slightly lower than its share, with values of 0.97 and 0.95 for papers published respectively in 2003 and 2000.

More recent data for 2007 publications with a citation window from 2007 to 2009 show that the gap has however reduced somewhat – the United States staying close to and slightly above 1.5 and the EU27 moving to 1.16. But if the population of the researchers in each region is taken into account, there is still an important difference: the average number of papers in the 10% most cited publications index per researcher is 2.25 for the United States versus 0.79 in the EU27.

The findings and conclusions of this section strongly suggest that if Europe wants to compete on an international level, it should focus more on the quality of research produced, by promoting and rewarding outstanding research performance in less rigid research structures.

[55] European Commission Directorate-General for Research (2008): A more research-intensive and integrated European Research Area, Science, Technology and Competitiveness key figures report 2008/2009, p. 64. Report available at: http://ec.europa.eu/research/era/facts/figures/key_figures_en.htm.

3. CURRENT NATIONAL AND EU LEVEL POLICY MEASURES

The intention of this section of the report is to clarify some of the ways in which the EU and selected Member States work to attract top scientists; i.e. how they seek to improve the attractiveness of their respective research environments and what initiatives they promote as part of existing or planned research programmes, strategies or policy initiatives as compared to those in selected competitor countries.

In the analysis that follows, we seek to identify the linkages between policy design and the attractiveness factors identified. The key question thus entails whether the national strategies, policy initiatives and activities respond to the main institutional or the personal / individual attractiveness factors that are relevant to top scientists. We will therefore examine the following aspects of current policies:

- **development of the innovation ecosystem and infrastructure, in view of their direct relation to the research environment**, e.g. creating/maintaining a competitive scientific environment (Quality of the research environment, Institutional reputation of the host institution, Availability of suitable research collaborators (including innovation ecosystem, social capital and network capacity), Industry linkages and links with companies and users of research;
- **conditions connected to research funding:** General availability and level of research funding nationally, Ability to access funding for a specific discipline / area of research;
- **addressing individual factors**: Personal incentives and remuneration, Salary and incentives, Working conditions, Pension and social care provision. Attractive labour regulations (e.g. working week, health and safety laws), Immigration regulations;
- **addressing factors indirectly impacting on the attractiveness of the R&D system**, such as quality of life and administrative factors.

The policy analysis that follows first looks at the current initiatives at the EU level (section 3.1) and then examines the key related aspects of the national context in the selected EU countries (section 3.2) and third countries (section 3.3). The objective here is to identify the strengths and weaknesses in relation to these national contexts and, ultimately, to provide a synthesis of these factors by assessing the role they may play more generally. The ways in which the related policies correspond to the main attractiveness factors that govern the choice of place of work for top scientists will be examined in section 4.

3.1. Overview of EU policies

European policies have been developed since the beginning of the 2000s with a view to raising the policy centrality of attractiveness and research mobility in the European system. In addition to funding instruments and support services, the EU has also sought to enhance working conditions and career opportunities by promoting a uniform set of rules and practices across the Member States. As a result, the European Charter for Researchers and a Code of Conduct for the Recruitment of Researchers were adopted by the European Commission as a Recommendation to the Member States in 2005.[56] The 'Charter and Code' define the roles, responsibilities and rights of researchers as well as those of their employers and the funding organisations.

They aim to guarantee attractive research careers and improve employment and working conditions for researchers throughout Europe.[57] To help the different institutions to implement the Charter and Code into their policies and practices, a Human Resources Strategy for Researchers was also introduced by the European Commission in 2008.[58]

The Scientific Visa Package introduced in 2005[59] facilitates the procedure of admitting researchers coming from non-European countries (third-country nationals) to Europe for the purpose of scientific research. The researcher target group that is addressed by the provisions of the Scientific Visa Package is defined as: a third-country national holding an appropriate higher education qualification which gives access to doctoral programmes, and who is selected by a research organisation for the carrying out of a research project for which the above qualification is normally required. Individual European countries do not have identical rules of procedure.[60]

In 2008, the European Commission introduced five ERA initiatives to help create the European Research Area[61]. One of these initiatives is the European Partnership for Researchers (EPR). The strategy was based on the argument that current EU initiatives such as the FP7 "People" programme (specific measures are discussed below) and the Code and Conduct are not enough to tackle the challenges related to researcher careers and mobility and that national level activities are needed to support the EU policy. The EPR aims to improve researcher career opportunities and mobility. It aims to accelerate progress in four key areas[62]:

- Open recruitment and portability of grants;
- Meeting the social security and supplementary pension needs of mobile researchers;
- providing attractive employment and working conditions;
- enhancing the training, skills and experience of researchers.

56 Commission Recommendation of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers.

57 Brochure: The European Charter for Researchers & the Code of Conduct for their Recruitment. http://ec.europa.eu/euraxess/index.cfm/rights/brochure.

58 Information Note from the European Commission "Human Resources Strategy for Researchers Incorporating the Charter & Code". 2008. http://ec.europa.eu/euraxess/pdf/hrs4r/Paper_on_the_HR_Strategy_for_Researchers.pdf.

59 Introduced through the EU directive 2005/71/EC and two subsequent recommendations 2005/762/EC and 2005/761/EC.

60 http://ec.europa.eu/euraxess/index.cfm/services/scientificVisa.

61 COM(2008) 317;s European Commission. 2009. The European Research Area Partnership 2008 Initiatives. http://ec.europa.eu/research/era/docs/en/era-partnership-european-commission-2008-initiatives-en.pdf.

62 http://ec.europa.eu/research/era/areas/researchers/researchers_en.htm.

The EPR will be implemented by the Member States and associated countries together with the stakeholders. Progress is monitored by the ERA Steering Group on Human Resources and Mobility. In order to monitor EPR implementation, the European Commission Directorate-General for Research commissioned a 3 year study in early 2011.[63]

In addition to the policy instruments above, the European Union has also launched information services for researchers in issues related to career opportunities and mobility. Of particular note here is EURAXESS[64], which is a joint initiative of the European Commission and the countries participating in the European Union's Framework Programme for Research. It provides a one-stop shop for researchers seeking to advance their careers and personal development by moving to other countries. In addition to the information on training and jobs, this electronic gateway is the entry point to a wealth of practical information on living and working in the European countries involved.

The most important instruments aimed at strengthening the European research effort have been the successive Framework Programmes of Research and Technological Development. These have always attracted high level European researchers. Scientists funded from the Framework Programmes tend to have a better publication and citation record than their non-FP peers.[65]

In the context of FP7, the current research Framework Programme, specific measures have been taken to support the integration of researchers and specific support has also been given to rewarding scientific excellence.

The training and mobility programmes for researchers, known as Marie Curie Actions (MCA)[66], are aimed at the development and transfer of research competencies, the consolidation and widening of researchers' career prospects and the promotion of excellence in European research. According to the report of the expert group in charge of the Interim Evaluation of FP7, MCAs "*….have promoted excellence and contributed to internationalisation efforts in Europe*"[67] and *"…set a valuable benchmark for the working conditions and employment standards of EU researchers."*[68]

An additional novelty of FP7 was the introduction of the ERC that was referred to in the background analysis of this study (section 1.1).

The ERC's Starting Independent Research Grants are dedicated to giving promising young scientists the opportunity to carry out independent research and to build up their own research teams. The ERC's Starting Grants can be applied for up to 5 years and entail funding of up to 300.000 Euro (exceptions up to 400.000 Euro) per year, for a total funding ranging from EUR 1.5m to EUR 2m over 5 years. Applicants can be researchers of any nationality, which at the time of the call are between 2 to 12 years beyond the completion of their PhD.

The ERC - Advanced Grants are given to established research leaders of any nationality and any age to develop innovative, high-risk projects. The researchers can be of any nationality and age. The main evaluation criterion is scientific excellence and the overall funding per grant is EUR 2.5m, while in some circumstances it may reach up to EUR 3.5m per grant over a 5-year period.[69]

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63 http://ted.europa.eu/udl?uri=TED:NOTICE:205089-2010:TEXT:EN:HTML.

64 http://ec.europa.eu/euraxess.

65 EPEC (2009), Bibliometric Profiling of Framework Programme Participants – Final Report, European Policy Evaluation Consortium (EPEC) for the European Commission, Directorate-General for Research.

66 MCA is a funding instrument for researcher training and mobility under the "People" Programme of the EU 7th Framework Programme http://ec.europa.eu/research/mariecurieactions/.

67 European Commission, Interim Evaluation of the Seventh Framework Programme, Report of the Expert Group, 12 November 2011, p. 30.

68 Ibid, p. 31.

69 http://erc.europa.eu/about-erc/facts-and-figures.

There is evidence that the ERC is effectively supporting world-class research: between 2008 and 2011, six of the 17 Europeans who were awarded prestigious research prizes were ERC grantees.[70] This aspect is recognised in the Interim Evaluation of FP7, where ERC is assessed as having successfully attained its objectives in respect of excellence and in attracting top researchers, but at the same time the very low success rate – in the region of 1-2% of all applicants – is recognised as an issue of some concern.[71]

Some of the top European scientists interviewed in the context of this study nevertheless recognised the value and the important benefits associated with the scheme in terms of the research means offered and the enhanced scientific reputation it offers to successful candidates. They did however also indicate that its very selective nature may be a negative factor in terms of generating applications from leading scientists as the time-consuming application process offers only a remote chance of success.

The very low success rate is associated with the clear focus on excellence, but it also relates to the total number of grants that can be supported within the overall financial envelope of the scheme and the large demand the scheme produced within the scientific community. In view of its high degree of acceptance and clear indications of high scientific impact, an increase in the ERC's budget would enable it to optimise the success rate and the associated benefits of the scheme.

3.2. EU Member States' analysis

In order to analyse the current situation, as well as to identify gaps in terms of policy responses we first need to set the stage for such an analysis by introducing the variations that exist between the countries included in our study sample. Our analysis will in fact show that there are important differences in the various national strategies considered (where they exist) and in the policy responses selected.

The variation in the level of importance placed on the issue of seeking to attract top scientists is also reflected in the various national policies considered here. In addition, even the general policies promoting R&D&I vary from country to country and these differences are reflected in the more specific policy choices on attractiveness. In some cases, there is a tendency to promote catching up (in R&D&I terms) rather than excelling, while in other cases, the R&D&I policies may not be particularly well developed or mature, but the issue of attractiveness is actively promoted. In some cases, the policy focuses entirely on developing the research infrastructure and providing a basic level in terms of research environments and human resources. In such cases, the issue of attracting top scientists or scientists in general may not be referred to at all, though there may be a hope that building a basic research infrastructure and investing even marginally in R&D&I may help to bring the research environments up to a level which is acceptable to top international scientists in the longer term. These differences explain our methodological choices in the documentary analysis, where we have included observations on the preconditions of attracting researchers (functioning research infrastructure and research environments), as well as policies and strategies addressing these, and (in cases where such initiatives exist) policies and strategies of more direct relevance to attracting top researchers (e.g. mobility grants, programmes for promoting excellence etc).

70 European Commission, 2011. Impact Assessment Accompanying the Communication from the Commission 'Horizon 2020 - The Framework Programme for Research and Innovation'. Commission Staff Working Paper . SEC(2011) 1427 final.

71 European Commission, Interim Evaluation of the Seventh Framework Programme, Report of the Expert Group, 12 November 2011, p. 66.

In the following section, we summarise the national policies in the various country cases chosen for further investigation, providing some basic information on their policy goals and instruments addressing the issues associated with attracting researchers and in cases where such information has been available, providing an overview of the ways in which the attractiveness factors have been taken into account in the national policy instruments and activities. These factors include, as summarised in the introduction chapter:

1) **Institutional factors relating to the research environment:** Quality of the research environment (people, facilities and resources) and institutional reputation of the host institution (e.g. international ranking), Availability of suitable research collaborators (including innovation ecosystem, social capital and network capacity);

2) **Institutional factors relating to funding**: General availability and level of research funding nationally, Ability to access funding for one's own research;

3) **Personal factors**, such as personal incentives and remuneration: Salary and incentives; Working conditions; Pension and social care provision, Attractive labour regulations (e.g. working week, health and safety laws), Immigration regulations;

4) **Quality of life factors**: e.g. Climate, Safety /security (low crime rate), quality of public services (healthcare, childcare);

5) **Other factors**: issues that impact on mobility, in most cases bottlenecks or hindrances, such as administrative obstacles (recruitment practices, visa policies etc), as well as cultural and linguistic factors (e.g. familiarity of language, cultural skills).

In what follows, we summarise some of the key characteristics of the countries selected for our sample, in terms of their R&D&I resources, researcher mobility and capacity, as well as some key features of their policy addressing the issues at hand, namely the attractiveness of their respective research environments for top scientists, as well as their national strategy and the main policy instruments used to implement it. The synthesis relies mainly on ERAWATCH reports and additional information and discussions with national experts and policy makers (referred to in the footnotes). ERAWATCH reports have been accompanied by other documentary sources and materials where available.

The analysis has sought to identify which attractiveness factors are most central in the case of the country in question and what are the main strengths and weaknesses identified that may affect the promotion of these factors.

The country sub-chapters follow a largely similar structure, where the background is provided by means of a brief summary of information on the governance structure (which ministries and agencies are responsible for R&D&I policy in general and measures addressing attractiveness to top researchers in particular) and policy background is further provided with a few key indicators (research expenditure etc.) After this introductory section, the measures and actions seeking to promote the creation of positive preconditions for attractive research environments are briefly outlined. The summary table lists the information on possible strategies for the promotion of the attractiveness of national research environments, the main policy instruments for attracting top scientists, as well as the attractiveness factors primarily addressed. The table also includes a synthesis of the strengths, opportunities and weaknesses (SWOT) identified, largely relying on the SWOT analysis of the ERAWATCH reports, though also on complementary data and materials where available.

3.2.1. Bulgaria[72]

Public support for research and the R&D&I level in Bulgaria is very low, with the Gross Expenditure in Research and Development (GERD) remaining at a steady albeit low level at 0.49 - 0.5% of GDP. The financial crisis has had a further negative effect on the public research budget.

The Ministry of Education, Youth and Science (MEYS) is the main actor in research and innovation policy in Bulgaria. Bulgaria has signed 13 bilateral science, education and culture agreements, and the signature of more agreements is foreseen. During the period 2002-2008, Bulgaria has implemented 52 science and technology projects in collaboration with India, 30 with China, 26 with FYROM 20 with Vietnam and 17 with Ukraine (MEYS data). The Bulgarian Academy of Sciences has also concluded 37 bilateral agreements, including 7 with countries outside Europe.

In recent years, the number of new partner countries and their collaborative research activates has increased. Exceptions to the current record of collaborative research participation include Turkey, the USA and Austria, all of with which Bulgaria has signed bilateral agreements however the collaborative programmes still have not been launched. The bilateral scientific collaboration agreements are implemented through the calls of the National Science Fund. The calls often list several eligible areas of research and can be characterised as either wide-ranging or generic in terms of topic type.

The Bulgarian Academy of Sciences has concluded 30 scientific bilateral agreements with European counties and 7 with countries outside Europe.

The EU-programmes are also an important instrument for research cooperation. The ERA-research policies are formally integrated into the national research policy documents and strategies. The research organisations, universities and PROs have increasingly better access to international knowledge through long-term agreements with their European counterparts, European research organisations and the Framework programmes, however these are primarily project-based and institutional support is limited.

[72] The summary relies on the ERAWATCH report of 2010, author: Daniela Mineva.

Table 4: Summary: Bulgaria

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– National strategy for scientific research up to 2020[73]. – Some policy instruments developing Centres of Excellence and clusters.	– Lack of national priorities makes it difficult to identify such factors, a more modest goal of making scientific careers more attractive and improving the status of researchers is included in the national strategy.[74]	– New Law on the Development of Academic Staff enacted in 2010 an opportunity. – Possibilities for international collaboration, co-publication and co-patent activities of Bulgarian and foreign researchers exist, mobility supported by the NSF and FP7, but absorption limited. – Attempts at improving quality and quality controls, e.g. an international evaluation of the Bulgarian Academy of Sciences (BAS) (2009); EU-review of NSF (2006); two evaluations of the universities; and introduction of a new rating system (launched in 2010).	– Low budget share of research in general, further exacerbated by the economic crisis. – No national priorities in research cooperation.

3.2.2. Estonia[75]

The Estonian governance model for research and innovation has at its core the Ministry of Economic Affairs and Communications and the Ministry of Education and Research. They are responsible for nearly all research funding streams and horizontal policies. The ministries collaborate with the Research and Development Council, which is an advisory body to the Government and makes the final expert decisions on all major R&D&I policy documents, and the Strategy Office of State Chancellery.

Estonia only attracts a low inward flow of researchers. Non-Estonian EU candidates accounted for less than 5% of enrolments at the doctoral level in 2005.[76]

The number of non-EU citizen doctoral candidates as a percentage of the total number of doctoral candidates in Estonia in 2008 was only 1%.[77] More recent data however suggests that mobility has increased since Estonia became an EU Member.[78]

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[73] The objective of the Strategy is to review the main problems facing scientific and research activity in Bulgaria. The Strategy determines the goals and measures in relation to securing a high-quality level of R&D and innovation through the establishment of a proper environment and encouraging companies to invest in scientific research; see: National Strategy of Scientific Research to 2020. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/bg/policydocument/policydoc_mig_0011?tab=template&avan_type=policydoc&country=bg.

[74] Ibid, p. 20.

[75] The summary relies largely on the ERAWATCH report of 2010, authors: Ruta Rannala and Katrin Männik, as well as on additional information received from Katrin Männik and Katre Eljas-Taal. See also the national innovation strategy "Knowledge-Based Estonia" at http://hm.ee/index.php?03242 and the ERAC Peer Review from 2012, http://hm.ee/index.php?048520).

[76] *Ibid*, p. 30, JRC-IPTS, 2008.

[77] Erawatch Country pages: Estonia (http://erawatch.jrc.ec.europa.eu).

[78] Government of Republic of Estonia, 2009, cited in the ERAWATCH report 2011.

The situation is rather different in taking into account the percentage of doctoral candidates of Estonian descent continuing their doctoral education in another EU country - the figure was one of the highest in the EU in 2004.[79] Financial issues are the main bottleneck in attractiveness terms and remain a problem both in terms of the national research environment and researcher mobility, including remuneration, stipends and infrastructure expenditures.[80] In addition to the full support given to doctoral studies through SCSP, PhD studies at foreign universities are also supported through instruments such as the Kristjan Jaak Scholarship programme.

Moreover, the DoRa programme for PhD students supports internationalisation (co-financed by the European Social Fund) amongst non-national doctorate students (16 scholarships in 2008-2009). The researchers' mobility programme *Mobilitas* issues postdoc grants enabling both Estonians to work in a foreign research and development institution and foreign postdoc researchers to work in RD&I priority areas in Estonia.

Estonia also actively participates in a wide range of international mobility programmes e.g. COST (European Cooperation in the field of Scientific and Technical Research). More than 100 researchers from the leading Estonian universities and research institutions participated in some 78 projects in COST actions across various research fields.[81] The total funds for COST and FP7 allocated to Estonian researchers in 2009 amounted to EUR 192m.

The Estonian Academy of Sciences and some of the universities are also members of the pan-European network of mobility centres - *EURAXESS*. In addition, the Archimedes Foundation administrates a mobility portal[82] which is targeted at foreign researchers and foreign students studying in Estonia.

In order to increase the mobility of third country researchers, legislative changes have been introduced including the scientific visa package, implemented by the Research and Development Organisation Act, and adopted by the Parliament on 26 March 1997. The Act is further supported by the Foreigners Act adopted by the Parliament in December 2009.

Policy instruments used to counteract the brain drain include scholarships offered through the *Compatriots' Programme*, which supports the studies of young expatriate Estonians in Estonia's public universities, national institutions of applied higher education and vocational education centres. Applications for scholarships are invited from young Estonians with secondary or higher education degrees, who have not resided in Estonia on a permanent basis during the previous 10 years.[83]

Actions to strengthen the research environment also include the 12 Centres of Excellence. The aim here is to support high level international research and the development of Estonian research institutions and ensure its sustainability, while also strengthening cooperation and the competitiveness capacity of Estonian research. The total cost of the Centres of Excellence is 49.02 million EUR.[84] These measures also utilise European Structural Funds.

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79 Ibid, 30-31. JRC-IPTS, 2008.

80 Archimedes Foundation, 2007, as cited in ERAWATCH report 2011.

81 *Ibid.*

82 www.smartEstonia.ee.

83 Study in Estonia compatriots-programme http://www.studyinestonia.ee/study/scholarships/

84 For more information, see: http://www.hm.ee/index.php?1512873 .

Table 5: Summary: Estonia

Strategy and main instruments for attracting top scientists	Attractiveness factors mainly addressed	Strengths / Opportunities	Weaknesses85
– Agreement on Good Practice in the Internationalisation of Estonia's Higher Education Institutions (2007). Provision of attractive employment and working conditions is viewed as a priority area by HEIs in Estonia. – RDI Strategy Implementation Plan. – National Innovation Strategy "Knowledge-based Estonia".	– More motivating remuneration and research environment for researchers and attractive conditions for Doctoral studies. – building a modern research and development infrastructure. – supporting the environment for high-tech entrepreneurship.	– National innovation strategy putting more impetus into attractiveness issues. – New opportunities opened up by Estonia's full membership of the OECD at the end of 2010.	– Brain drain. – Financing and wage level. – Lack of competent high-skilled labour.

3.2.3. Finland[86]

The Finnish government's research and innovation policy is supported by a high-level advisory body, the Research and Innovation Council. The ministries with responsibility for research policy are the Ministry of Education and Culture and the Ministry of Employment and the Economy. Below these levels, there are the funding organisations organised as state agencies, the Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation.

Mobility and the immigration of foreign professionals to Finland have remained on comparatively low levels. The number of foreign doctoral students was only 1,737 in Finland in 2006, although increasing annually by 5%[87]. Also the share of students from abroad has stayed on a rather moderate level in Finland, only 8% (in 2007), especially when compared with 22.5% in the EU27.[88]

Within the same period, the inflow of foreign researchers and teachers to Finnish universities amounted to 1,172 people (1,153 in 2000). The inflow of researchers has still been greater than the outflow of Finnish researchers. In 2009, the outflow of domestic teachers and researchers (long visits over 1 month) amounted to 699, with a tendency to decrease. For instance, in 2000 there were still 741 visits exceeding a month.[89]

Financing to support the outflow of researchers is also provided by the Academy of Finland and Tekes. For specific mobility support, the use of EU mobility schemes is promoted. Regardless, the Finns are among the least mobile researchers in Europe though there are policy goals and strategic objectives now in place that seek to overturn this trend. Such policy objectives have been formulated for instance in the National guidelines for the Research and Innovation Council[90] while the governmental programme also, for instance, mentions the need to ensure that recruitment policies are developed in a way that makes

85 Mainly identified on the basis of the analysis of the ERAC Peer Review from 2012.
86 The summary relies on the ERAWATCH report of 2010, authors: Kimmo Viljamaa and Henri Lahtinen.
87 Eurostat 2010.
88 Education database "KOTA", 2010. See also Study on mobility patterns and career paths of EU researchers, Report II, technical report, p. 210, Table on overall international mobility rates in EU26, excluding France.
89 KOTA database 2010, cited in Viljamaa 2011, p. 25.
90 Research and Policy Innovation Guidelines 2011-2015.

research careers[91], both studying and working in Finnish universities and Higher Education Institutions, more attractive.

The inability to attract research professionals to Finland has been identified as a challenge to be addressed and some policy measures have been taken in recent years. The strategic guidelines and objectives set have been included in documents such as the internationalisation strategy drafted by the Research and Innovation Council (2009) and the Research and Innovation Guidelines for 2011-2015.[92]

On the operational level, as is the case in most European countries, a considerable amount of the effort put into promoting the attractiveness of Finland as a research venue and in recruiting top international scientists has been bilateral in nature. There are however a number of programme-based instruments that have been developed to address the attractiveness issue, such as the FiDiPro - the Finland Distinguished Professor Programme, introduced as part of the package of new legislation for the promotion of public research in 2005.[93] The aim of the programme is to provide Finnish universities and research institutes with the opportunity to employ distinguished professor-level scientists from around the world for a fixed term to carry out research and contribute to the advancement of scientific research.[94] Foreign professionals are also able to receive a slightly more favourable tax rate.[95] A new initiative was also introduced in 2012 for small and medium-sized companies to claim tax reductions for research investments[96], which is likely to support the attractiveness of the research environment, while not targeting the individual level as such. While the total volume of the FiDiPro initiative is relatively limited, i.e. approximately 17 million euro annually, it is seen as a promising step in the right direction to address a serious limitation in Finnish competitiveness.

It is usually argued that the main weakness in terms of attracting foreign experts to Finland lies in the harsh nature of the climate and linguistic barriers, which are naturally difficult to influence. The attractiveness factors addressed by the Finnish government and research organisations have focused more on easing the way for top individual scientists who do come to Finland by creating and maintaining excellence in the form of a competitive scientific environment, as well as focusing on the quality of life factors (e.g. security, safety and family-friendliness).[97]

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[91] An action plan for making research careers more attractive was launched in 2007. This is not referred to in the current governmental programme and the budgetary cuts in the R&D sector may have undermined these efforts in recent times.

[92] Research and Innovation Council of Finland (2010).

[93] The programme is based on the Government Act of 07/04/2005 on the structural development of the public research institutions. Source : The Council of State decision on the development of the structural principle of the public research system, 7 April 2005.

[94] *Ibid*.

[95] A foreign employee can choose between a normal income and a tax at source for no more than 24 months. The tax at source is 35% of the total amount of salary. This system is advantageous to employees with high salaries. It has been mainly applied to a small group of foreign experts employed by firms, much less if at all to researchers employed by universities and government research institutes. (Source: ERAWATCH, Lahtinen & Viljamaa 2011).

[96] Introduced as a tax-break for R&D investments in the unlisted SMEs from the beginning of 2013.

[97] Research and Innovation Council of Finland (2009): Internationalisation of Finnish Education, Research and Innovation. Available at: www.minedu.fi/export/sites/default/OPM/.../KVstrategia_Eng.pdf.

Policy Instruments: Finnish examples

Finnish Distinguished Professor Programme

FiDiPro Fellow funding is designed to attract talented and experienced international researchers past their postdoctoral stage, thereby well fitting the ”top scientist” focus of our study. The programme is co-financed by Tekes and the Academy of Finland. In total, these two organisations have funded 87 professors or FiDiPro fellows between 2007 and 2011, with an annual budget of approximately 17 million Euros. There have been a large number of nationalities represented among the professors, with the USA and Sweden seeing the largest representations thus far.

The commitment of the recipient institutions is significant, as it is the Finnish universities and research institutes which propose FiDiPro Professors and FiDiPro Fellows from all disciplines.[98] Thus, every top scientist has a host institution to go to and a project is set up where the international expert can work together with his or her Finnish colleagues. Tekes and the Academy of Finland open calls on a regular basis. The application for funding is always made by a Finnish university or research institute and not by the international researcher personally.[99]

According to the information available from the FiDiPro homepage, the instrument “offers competitive grants covering FiDiPro Professor's or FiDiPro Fellow's salary and travel expenses, research costs and related expenses of accompanying family members. It is possible for the FiDiPro professors to bring along a key member or key members of their own research team, whose expenses may also be partially covered”[100].

The implementation model is different from other financial instruments funded by the Academy of Finland, where it is the applicant who is also the Principal Investigator of a project. FiDiPro funding is applied for by research organisations, universities and research institutes. The FiDiPro instrument thus also supports the organisations' structural renewal in the form of development and internationalisation. The instrument supports the profiling of strengths in the organisation and strengthens the focus on internationalisation, which has often been found to be the weakest link in Finnish research organisations.

FiDiPro also comprises an innovation element, with the universities and research institutes being encouraged to collaborate with each other and with business and industry.

There is no specific scientific visa system in Finland. All EU and EEA researchers are free to move to Finland, while researchers from other countries need a regular work permit if they stay in Finland for more than 3 months. This is sometimes identified as a bottleneck. The remuneration issues are less of a bottleneck today when the universities and research organisations are free to set their wage levels and consider individual cases for compensation.

The Ministry of Education and Culture seeks to promote internationalisation and participates in the development of the European Research Area by actively supporting the networking activities of national research programmes. At the operational level, the key to this effort has been the development of the centre of excellence policy, the networking and opening-

98 http://www.fidipro.fi/pages/home/fidipro-at-a-glance.php.

99 http://www.fidipro.fi/pages/home/fidipro-at-a-glance.php.

100 http://www.fidipro.fi/pages/home/fidipro-at-a-glance.php.

up of research programmes, the setting-up of joint research programmes with other countries and the promotion of researcher mobility. The policy has consisted first and foremost in ensuring the promotion of excellence and high quality of research, which is expected to bring about internationalisation, as the research environments become internationally renowned and international networks more dense.

The Academy of Finland has supported international S&T cooperation for a considerable period of time and its funding opportunities are intended to promote the international networking and activities of Finnish researchers, and to support them in their international collaborations in foreign universities and research institutes.[101] One of the key activities in this respect is maintaining several bilateral or multilateral agreements with funding organisations. The Academy has established bilateral agreements with China, Estonia, Germany, India, Japan, Russia, and Taiwan. The universities also have several international agreements, though these are mostly focused on student exchange. Additionally, the Academy is closely involved in planning and implementing the work of the Nordic research funding organisation - NordForsk.

Table 6: Summary: Finland

Main policy instrument/ strategy for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– Making research careers more attractive by renewing the preconditions and structures, more active recruitment policies and ensuring the quality of research in prioritised research areas (e.g. centres of Excellence, Cluster initiatives such as Centres of Expertise and Strategic Centres for Research and Innovation), objectives outlined in the Strategic Guidelines drafted by the Research and Innovation Council (RIC). – Other instruments: Finnish Distinguished Professor (FiDiPro). – Strategic Centres for Research and Innovation (SHOK).	– Quality of the research environment (people, facilities and resources).	– High public and private research expenditure. – Attractive in some research areas with high specialisation. – Good brand, quality of life issues (safety, security, childcare, basic education etc.).	– Funding to basic research and research infrastructures has grown more slowly than funding to applied research and innovation. Recent budgetary cuts have further exacerbated this trend. – For international recruitments high tax level and (for non-EU citizens) restrictive visa policy. – The level of support for international recruitments and FiDiPros highly dependent on the HEI in question, relatively little support from the funding organisations. [102]

[101] Ahonen et al. (2009), Internationalisation of Finnish scientific research, p. 56.

[102] It was agreed by the experts in the funding organisations responsible for FiDiPro interviewed in connection with this project (Hannele Kurki at the Academy of Finland and Hanna Rantala at Tekes) that the building of networks is still highly dependent on individuals. Consequently, it might be a very slow process, especially if the level of institutional support is weak. Different types of matchmaking activities and activities aiming at making Finnish research organisations more internationally visible were also mentioned by the interviewees.

3.2.4. Germany[103]

As described in The ProInno reporting, "The governance system for research and innovation policy in Germany involves both Federal and State level actors (centralised and decentralised, *Bund* and *Länder*). There are several co-ordination mechanisms, stakeholder groups and expert councils involved in the system, with the key actors in research and innovation policy being the Federal Ministries such as the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Economics and Technology (BMWi) while several other Federal Ministries (e.g. Ministry for the Environment, Defence Ministry), as well as the Federal Chancellery. In the course of the High-tech Strategy implemented in 2006, a so-called "Research Union" was established to supports policy by identifying challenges and formulating adequate responses. In 2007, a new Expert Council for Research and Innovation (EFI) was created, which presented its first report on the state of research and technology in Germany in February 2008 and its second report in March 2009".[104]

Germany is one of the leading countries when it comes to R&D&I and also ranks highly in terms of international attractiveness. In terms of research expenditure, Germany has the largest research system in the EU. In 2008, Germany's GERD was about EUR 66.5b. Germany also contributes significantly to EU resource mobilisation, being responsible for about 28% of aggregate EU-27 research expenditure in 2009.[105]

Despite being able to attract foreign researchers, Germany faces severe brain drain problems.

Two issues constitute the main challenges for young professionals: the underdeveloped nature of the tenure track as well as difficulties in outlining an academic career path at universities. Permanent positions as independent researchers remain hard to acquire because short term contracts are the standard procedure.[106] This clearly hinders the recruitment of skilled young researchers. A few new measures – for example the introduction of career paths for postdocs (*Juniorprofessor*) - have been initiated to block the brain drain flow (mainly to the USA).[107] Implementation has not, however, lived to the expectations. This resulted in the introduction of a new law on temporary contracts in science in 2007. The law reverses the 12-year limit for temporary work contracts. This is the case if the work is for instance mainly linked to a project funded by a third-party. The change has not been significant since only one fifth of university teachers receive permanent positions.[108]

Furthermore, a range of research programmes have been established at the federal level. These encompass measures designed to support promising groups of young researchers. For instance the "Pact for Research and Innovation" provides more support for junior researchers in public research organisations.[109] A monitoring report from 2008 indicates achieved improvements. Greater efforts to attract talented and well qualified foreign scientists have, however, been called for. This is expected to result in brain gain – especially concerning German scientists working abroad.[110]

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[103] This section and the German analysis is based on the ERAWATCH Country Reports 2010: Germany by Birgit Aschhoff, Christian Rammer.

[104] www.proinno-europe.eu/page/innovation-and-innovation-policy-germany.

[105] ERAWATCH Country Reports 2010: Germany, op.cit., p. 2.

[106] ERAWATCH Country Reports 2010: Germany, p. 36.

[107] *Ibid.*, p. 36.; http://www.bmbf.de/en/820.php.

[108] Bonner Presseblog, 2008.

[109] ERAWATCH Country Reports 2010: Germany, p. 36.

[110] ERAWATCH Country Reports 2010: Germany, p. 36;GWK, 2008 and 2010.

As indicated in the report of the European Commission on the remuneration of researchers in the public and private sector, working in Germany stands for one of the highest salaries for a researcher in Europe. For instance in 2006, the average total annual salary of a researcher was EUR 56,132 while the EU-25 average was only EUR 37,948.[111] The cost of living in Germany, however, has a negative effect on the pay roll, dropping the average salary to EUR 53,358. The average EU-25 salary increases to EUR 40,126. Regardless of the cost of living, Germany can be considered a country with high remuneration levels (EUR 40,000-60,000). The level of income in Germany is, however, far from that of the USA (EUR 60,156 or EUR 62,793, taking into account the cost of living). The public research system cannot compete with the salaries paid by private enterprises.

Several instruments are also in place supporting the attractiveness of research environments. As a result of the measure "Pact for Research and Innovation" a EUR 1.9 billion funding package from the federal and state funds has been allocated to selected higher education institutions between 2006 and 2012.[112] Non-university research institutes have also received additional funding of around EUR 2.3 billion through federal and state funds from 2006 to 2010. The federal and state governments reached an agreement concerning the second programme phase of the "Higher Education Pact 2020", the continuation of the "Initiative for Excellence" as well as the "Pact for Research and Innovation" in 2009. The three measures are expected to reach the total funding volume of EUR 18 billion by 2019.

The main policy instruments encompass the following examples of policy tools for Cooperation and Return.

[111] European Commission, 2007.

[112] Federal Ministry of Education and Research, 2009.

Policy Instruments: German examples

Alexander von Humboldt-Foundation[113]

The Alexander von Humboldt-Foundation funds scientific cooperation between excellent foreign and German researchers. It grants research stipends and prizes enabling scientists to come to Germany from abroad to carry out a self-selected research project together with a host and research partner. Scientists from Germany as academic fellows can realise a research project as guests of one of the 24,000 alumni in the Humboldt network. Scientists from over 130 countries belong to the network of the Humboldt foundation.

Selected funding opportunities for postdocs also include **Policy instruments addressing the return of German Researchers from abroad** (*Rückgewinnung deutscher Wissenschaftler/innen aus dem Ausland*) seeking to help German researchers to return to Germany. Two independent funding schemes are offered:

1. Travel support (subsidies): for a) invitations to job interviews and b) invitations to give lectures at universities or scientific institutes.
2. Return stipend for the scientific integration: A 6-month return stipend to support German scientists to restart an active scientific occupation in Germany after a mobility phase abroad, and also for those who would like to return to the science and research system.

Return stipend for those funded by the DAAD. In the second year of funding by the DAAD, travel support can be granted to help intensify scientific contacts with Germany. Also to ease reintegration 6-month transition support can be granted to stipend fellows who are without employment and funding, after returning from a stipend-supported stay of more than a year.

International education and study partnerships (ISAP)

The goal of the ISAP is the creation of institutional cooperation between German and foreign universities, where groups of highly qualified German and foreign students can complete parts of their degree at a partner university. Their work is fully accredited towards their degree.

With the Academic Freedom Act (*Wissenschaftsfreiheitsgesetz*), additional steps are made to render the research infrastructure more attractive. As described in the ERAWATCH report of 2010 "The new law enables institutions to offer more flexible contracts to researchers. The aim is to enhance Germany's attractiveness in international competition for scientific systems and innovative centres. Furthermore, in order to enhance the German research infrastructure, the federal government will be providing the states with just under EUR 1b a year until 2013 for the further development of the infrastructure at higher education institutions."[114]

[113] Humboldt Foundation 2009.
[114] ERAWATCH COUNTRY REPORTS 2010: Germany, p. 25.

Table 7: Summary: Germany

Strategy and main instruments for attracting top scientists	Attractiveness factors mainly addressed	Strengths / Opportunities	Weaknesses[115]
– Continuation of "Higher Education Pact 2020" to create 275,000 additional university places between 2011 and 2015, funding for 39 graduate schools for junior scientists between 2006 and 2010 within the "Initiative for Excellence", new support scheme for highly talented students and for lifelong learning, further opening of the labour market. – The main instruments are summarised in the info box above (Policy Instruments: German examples).	– Internationalisation incorporated in an explicit Government strategy since 2008, there has also been an increase in bilateral agreements on cooperation in education and research with other countries. – In 2007, an instrument was introduced to attract world-leading international researchers (up to EUR 5m and up to 10 awards per year; Alexander von Humboldt professorship).	– Attractive working conditions for researchers (good RIs, high remuneration level). – For developing research environments, research, innovation and education policy have been exempted from cuts in federal budgets so far, though science and education budgets have been cut in some states;. – Stagnating institutional funding of universities.	– Difficult to gain a permanent position, no tenure track system for researchers, low share of students and graduates relative to OECD average, low share of foreign professors compared to the (main perceived competitors) the USA and Switzerland, low share of female researchers relative to the EU average.

3.2.5. Greece[116]

In the Greek governance system, the main responsibility for research policy rests with the General Secretariat for Research and Technology (GSRT) of the Ministry of Education, Lifelong Learning and Religion. The GSRT funds and supervises public research centres constituting approximately 20% of the national effort. It also designs and funds R&D&I measures targeting both the public and the private sector.

The overall number of research personnel in Greece remains quite low. Research personnel (FTE) constitute approximately 0.42% of the active population in 2007, as compared to the EU-27 average of 0.61%. The university sector creates demand for researchers by absorbing 60% of the researcher workforce. In total, the public sector employs close to 69% of the researchers, leaving 29% for the business sector. The rest of researchers (2%) are employed in private non-profit organisations. In the EU-27, the share of the business sector is considerably higher and equals to 46% of research personnel. The much lower demand for researchers by the Greek private sector is, therefore, the main reason for the lower overall share of research personnel with respect to the active population in Greece as compared to the EU-27 average. "Limited demand for researchers by the private sector in Greece can be attributed mainly to the low knowledge demand due to the orientation of the Greek economy towards low- and low-to-medium technology sectors and less knowledge-intensive services."[117]

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[115] Mainly identified on the basis of the analysis of the ERAC Peer Review from 2012.

[116] This section relies primarily on the ERAWARCH Country report Greece 2010 by Nikos Maroulis and Eleni Mikroglou.

[117] ERAWARCH Country report Greece 2010 by Nikos Maroulis and Eleni Mikroglou. p. 32.

The outward mobility of Greek researchers has however been consistently high, especially in respect of the USA. Greece was ranked 10th among the EU Member States in terms of researchers relocating to the USA. Among American scholars, those of Greek origin represent approximately 2.5% of the researchers in the entire HEI and government sectors.[118]. The number of Greeks doing PhD studies in another Member State as compared to the PhD candidates in the country is among the highest in the EU.

The only nation passing Greece is Ireland.[119] The same study was conducted in 2005, and discovered that Greeks pursuing a PhD in the USA represented 8% of all Greek PhD students. Three years later, however, this share had decreased by half to 4%.[120] The MORE study additionally revealed the very high share of researchers (73%, the third highest share among EU-27 countries, 2010) in Greek universities that have worked in a country other than the country where they attained their highest educational degree (PhD or postdoc).[121]

Numerous attempts have also been made in the last 30 years to create more favourable conditions to help attract distinguished Greek scientists living abroad back to the country. Such efforts were included within government policies to increase the number of universities in Greece and the corresponding research infrastructure. Already in the 1980s, such measures sought to target top scientists from the USA and to a lesser extent those from EU countries. As a result, research laboratories with an international exposure were developed in the major metropolitan areas of Athens and Thessalonica and in cities like Patras, Iraklion and Chania from 1980 to 2000.

More recent measures to attract scientists from abroad include programmes that were launched by the General Secretariat of Research and Technology (GSRT) in 1997 and in 2004. The first addressed Greek speaking researchers living abroad, by funding "relocation" projects of up to 150,000 Euros for the duration of 3-4 years per project. According to statistics released by the GSRT, out of 171 applications, 60 projects have been funded, leading to 10 permanent positions in Greek universities and research centres. The second related programme addressed "distinguished" international scientists from abroad working in selected sectors of importance for the Greek economy and created considerable demand from scientists with Greek and other nationalities. The programme ran until 2008 and its evaluation, which should include outcomes and effects in terms of permanent positions, is expected to be conducted in the frame of the mid-term evaluation of the Competitiveness Operational Programme of the Greek National Strategic Reference Framework 2007 – 13.

The brain drain seems likely to continue into the foreseeable future. The economic crisis has thrown up a further bottleneck in terms of renewing the R&D&I policy in such a way as to effectively impact on the attractiveness issues outlined above. While Greece has historically close connections with some European countries, these tend not to be the leaders in terms of attractiveness and they are therefore not likely to have a positive impact on the issue of attractiveness factors.

Due to the current fiscal constraints, Greece has very little room for manoeuvre in terms of attractiveness promoting measures. Already prior to the crisis, a low level of attractiveness existed due to the reality of the working conditions faced by researchers. The more recent cuts in terms of salaries and the reduction in public investment has simply further reduced the attractiveness of research jobs. The European Charter of Researchers issued by DG

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[118] *Ibid*, p. 32.

[119] Moguérou and Di Pietrogiacomo, 2008.

[120] MORE, 2010a.

[121] *Ibid*, p. 33.

Research in 2005 has been signed by only two out of the 16 public research organisations and three out of the 23 universities and 15 technological education institutes.[122]

The current crisis is expected to continue to impact the employment of researchers negatively, as companies combine cutting of research budgets with efforts to increase productivity. Furthermore, hiring in the public research sector has recently been stopped until at least 2013, due to the strict austerity programme currently being undertaken, which has blocked the hiring of new personnel in the public sector. Until the relaxing of the measure, personnel will be hired only on a project basis.

However, some policy measures were promoted during the first years of the crisis. These included a new multi-annual programming instrument, the National Programming Framework for Research and Innovation (NPFRI), which sought to integrate all of the research and innovation objectives and activities of the ministries into a single action plan targeting selected national priorities.[123] A clearly picture is expected to emerge in respect of these instruments after the elections of June 17th 2012.

Table 8: Summary: Greece

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– No specific measures at present.	– Research infrastructures. – Scientists with international presence (senior editors in reputable scientific journals, leading positions in EU and international networks).	– Relatively high involvement in European cooperation through COST, ERANET and FP7.	– Economic crisis and further austerity measures further accentuating the brain drain problems. – Working conditions in terms of work environment and infrastructure, support facilities and remuneration are unattractive as compared to other European countries. – Constraints include the requirement to be fluent in Greek in order to attain a position in the public research system.

[122] Maroulis and Mikroglou (2010), p. 34.

[123] The main funding directions of the NPFRI are: research projects in specific research priorities, support for innovation, development of an integrated research area, development of research infrastructures and development of human resources in research (GSRT, 2010, p. 16); see also: http://www.gsrt.gr/default.asp?V_ITEM_ID=4699)

3.2.6. Italy[124]

The high-level steering of R&D&I policy in Italy is organised around the Council of Ministers and the Inter-Ministry Committee for Economic Planning (CIPE). The operational level is overseen by two ministries: the Ministry of Universities and Research (MIUR)[125] is responsible for the coordination of national and international scientific activities and as well as the distribution of funding appropriated to universities and research agencies. The MIUR also establishes the means by which support via public and private R&D&I funding is made. The Ministry for Economic Development supports industrial research by managing the financial tools of intervention in industrial research.

In 2007, the MIUR became a part of the Inter-ministerial Committee for Economic Planning (CIPE).[126] The key actors also include the PROs, which play a very significant role in the research sphere. In 2009, a government decree reforming the PROs under the MIUR supervision was passed[127], to oversee the setting up of new internal statutes and undertake a reform of the governance system and multiyear planning of the activities associated with the pursuit of scientific excellence and greater integration with private sector research.

Italy's research expenditure is relatively low when compared to the size of its economy. In 2009, the GERD/GDP for the EU27 amounted to 2.01%, clearly exceeding the ratio of Italy (1.27%). In terms of the Higher Education Research and Development, the figures are more even. HERD as percentage of GDP was a little higher in Italy (0.48%) than in the EU27 (0.4%) in 2009.

Research careers in Italy have not historically been seen as attractive, which has led to a considerable brain drain of Italian researchers. Therefore the 2010-2012 National Research Programme attached high importance to human resources in science and technology by proposing the following:

- "to reserve a quota of 20% of funds for basic research for young people;
- to offer young researchers and postdocs an experimental route in terms of being integrated into permanent careers (procedures for placing young researchers into university roles have been introduced under the Extraordinary Plan for Recruitment of Researchers contemplated by the 2009 Budget Law, for which EUR 40 million has been allocated);
- to favour the return of Italian researcher from abroad and the adoption of foreign scientific competences;
- to sustain the international doctoral schools;
- to sustain the present doctorate courses, after a performance evaluation." [128]

Italy is not that often chosen as the country in which to conduct research by foreign researchers. Only 1.8% of all researchers in Italy are foreign, although notable differences exist within various fields of science (e.g. The National Institute for Physics). There are far more Italian researchers pursuing research careers abroad. . The difference is even more significant in the case of foreign doctoral students. In 2001 only 29,000 foreign students

[124] The summary relies on the ERAWATCH report of 2011, authors: Bianca Potì, Emanuela Reale, as well as information kindly provided by Julie Pellegrin and colleagues at the Centre for Industrial Studies, Milan.

[125] More information on MIUR and its structure at: www.miur.it/organizzazione/default.aspx.

[126] The CIPE is the highest level of S&T policy coordination, especially competent on inter-sector and medium term interventions. The CIPE examines the document of economic and financial policy (DPEF), which establishes strategic direction and priorities for scientific and technological research, financial resources and coordination among different public administrations, universities and research institutes. It includes the economic and financial measures for the following year, and is submitted by the Ministers' Cabinet to the Parliament each year.

[127] D.lgs 213/2009.

[128] ERAWATCH Country report 2010 by Bianca Potì and Emanuela Reale, p. 21.

participated in PhD courses in Italy, compared with 40,000 in Spain, 226,000 in the UK and 475,000 in France.[129]

The visa directive regulating the admission of researchers coming from abroad for the purposes of carrying out a research project within an Italian research organisation has been implemented in Italy since 2008.[130] Short-stay VISAs exist for researchers. A longer-term admission, however, requires the existence of a temporary position within a research institution in Italy. These positions commonly have a link to specific research programmes.

Over the past 10 years, the Italian Government has utilised three types of policies to address the problem of brain drain: return, retention and networks. The key policy features of each are described below.

Policy Instruments: Italian examples

RETURN POLICY

In 2001, the first programme to reverse the brain drain phenomenon was launched[131]: it was aimed at providing incentives to sign contracts between Italian universities and foreign or Italian academics and experts regularly engaged in teaching and research activities abroad for at least three years. The contracts (from a minimum of 6 months and up to 3 years) had to include both research and teaching activities. The universities should work to provide adequate reception facilities and to support the contractor's activities. Also, they had to commit themselves to co-finance 10% of the costs of the contractor's research programme. The Ministry of Universities has in return the responsibility to pay the contractors' wages, which had to be in line with the European wage levels. Tax exemptions were also introduced to address the brain drain issue.

In 2010, a new piece of legislation[132] introduced further tax incentives for the return of workers to Italy. This initiative is broader than simply addressing researchers wanting to return; it provides incentives for workers across the private sector, both employees and entrepreneurs that want to establish business activities in Italy.

RETENTION POLICY: IIT example

In 2003, a similar legal proposition was put forward to that described above (in conjunction with the Return Policy), laying down the guidelines for the creation of the Italian Institute of Technology (IIT), an institute designed on the MIT model, dedicated to applied technological research and intended to facilitate interaction between research and industrial worlds.

POLICY NETWORKS: Davinci example[133]

A third policy undertaken by the Italian government was designed to create an organisational network for Italian scientists' working abroad. In 2003, a conference was organised for Italian scientists around the world, with the aim of laying the foundations for the creation of a network to connect them with their homeland. The conference introduced the DAVINCI network of Italian researchers working abroad in university centres, industrial laboratories, and international organisations. DAVINCI is a database accessible via the Internet that is coordinated by the Italian Ministry of Foreign Affairs and includes data on the activities, research interests and expertise of Italian researchers working abroad. The content of the database is provided by the researchers themselves.

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129 MIUR, 2005.

130 European Commission Directive 2005/71/EC, applied in Italy under the D.Lgs n. 17/2008.

131 Article 1 of the Ministerial Decree of 26 January 2001, N. 13; Ministerial Decree of 20 March 2003 and the Law N. 326 of 24 November 2003.

132 The Law 238/2010.

133 More information on DAVINCI Database Initiative available at: http://www.esteri.it/davinci/index.asp?lang=eng.

Bilateral and multilateral agreements represent the most significant instruments in the national R&D&I internationalisation strategy. Bilateral agreements have been established between public and private institutions to improve the research coordination between Italian and foreign scientific organisations. About 70% of the agreements have been established by the Ministry for Universities (MIUR) and the Ministry of Foreign Affairs with foreign scientific institutions. As to the non-EU countries, Italy has bilateral agreements with Pakistan, Saudi Arabia, Jordan, Qatar, the USA, Argentina, Canada, China, Egypt, Morocco, Japan, and Tunisia. Cooperation is carried out via the negotiation of Executive Programmes for Scientific and Technological Cooperation within an intergovernmental Framework Agreement on Cultural, Educational, Scientific and Technological Cooperation.[134]

Table 9: Summary: Italy

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– New laws introduced seeking to influence the brain drain and to some extent even reverse it. – IIT established and PROs status developed in order to promote better integration and coordination between public and private sector research.	– The working conditions of (in particular young) researchers. – Main focus on personal level attractiveness factors.	– Measures[135] introduced specifically to favour the recruitment of young researchers in universities and to support well-performing universities through the more effective use of formula funding.	– Low level of R&D&I, further diminished by the crisis. – Overall unattractive working conditions for researchers, low salaries, difficulty of gaining permanent positions.

134 Source: http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/it/country?section=InternationalisationOfSTCooperation&subsection=Instruments.

135 Law 1/2009.

3.2.7. Portugal[136]

Portugal made considerable progress throughout the early 2000s in the R&D sector. Despite Portugal's economic weaknesses and the current economic and financial crisis, both GERD (Gross Expenditure in Research and Development) and BERD (Business Expenditure in Research and Development) experienced significant growth rates. GERD was only 0.83% in 2003, and it increased to 1.7% of GDP in 2009. The BERD reached 0.8% of GDP, marking a steady increase from 2003 (0.2%).[137] There are however a number of weaknesses associated with the absorption capacity in relation to these investments though such issues are beyond the scope of this study.[138]

Portugal has extensive bilateral collaboration in research mobility with a number of European countries. Most of the agreements focus primarily on the mobility of researchers, and most are not addressed to specific scientific fields. One exception is the agreement between the FCT (Portuguese Foundation for Science and Technologies) and the British Council.[139]

Instead of the traditional approach (basic support to researcher mobility), bilateral cooperation has recently been developed in Portugal as means of conducting joint research initiatives. This has led to the emergence of a new generation of bi-lateral or even multi-lateral agreements. Joint calls and initiatives, such as the Iberian International Nanotechnologies Laboratory (INL) and knowledge-based bio-economy (KBBE), have been implemented with other European countries to promote joint research projects in some specific fields. The former is a joint programme with Spain, aimed at promoting Portuguese-Spanish cooperative research projects in nanosciences and nanotechnologies while the latter stands for a cooperation agreement between Portugal, Spain and France for joint projects focusing on knowledge-based bio-economy.

The most relevant initiative in terms of cooperation with non-ERA countries is the series of agreements with three major US universities. Furthermore Portugal has established scientific cooperation agreements with several countries, such as Brazil.

The cooperation process has been strengthened and enlarged of the cooperation process and the opening up of research programmes is further envisaged.

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[136] The summary relies on the ERAWATCH report of 2010, Authors: Manuel Mira Godinho and Vítor Corado Simões

[137] GPEARI, 2010b, 2009b, cited in Godinho & Simoes 2010, p. 3.

[138] The main barriers to private R&D investments in Portugal are associated with the structural characteristics of the economic fabric, the size distribution of Portuguese firms (lack of large firms), the nature of the domestic demand, weak company absorptive capacity and insufficient development of the venture capital market. (Godinho & Simões 2010, op.cit.).

[139] The fields of collaboration are: Genomics and biotechnology; ICT and information Society; Nanotechnologies; Aeronautics and space; Food quality and security; Environment, sustainable development, ecosystems, and climate change; and Marine sciences and technologies.

Table 10: Summary: Portugal

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– 'Partnerships for the Future' programme, with joint programmes with the following US organisations: MIT; Carnegie Mellon University; University of Texas at Austin; and the University of Harvard.	– All attractiveness factors used in this study are relevant. – The USA-Portugal programmes have included as their objectives the following: 1) Improving educational and training ability, 2) Increasing the number of national consortia, 3) Promoting internationalisation, 4) Strengthening the recruitment of professors and faculty, 5) Promoting economic growth through science-based innovation, 6) Attractiveness (addressed as a separate explicit goal of the agreements), and 7) Access by Portuguese companies to international markets.	– Increasingly competitive for foreign researchers in the 30- to 40-years old cohort. – High share of female researchers. – Strong growth in the share of PhD holders in active population. – Research capacity improved by Creation of Iberian International Nanotechnology Laboratory (INL) and Creation of Champalimaud Research Centre (with the help of private foundation of the same name) . – Universities reformed, associated laboratories evaluated. – International recruitments through initiatives such as 'Partnerships for the Future' with US universities and Fraunhofer Gesellschaft, Promotion of participation in FP7 and creation of the UNESCO Centre for doctoral education of Portuguese speaking researchers.[140]	– Difficulty in generating employment and promising career prospects for young PhD holders. – High pressure on the USA-PT programmes, as these have been considered very costly for Portugal in the current circumstances.

[140] Tensions have emerged between the agreements with US universities and European research policy, since such partnerships address several areas with European value added and involve funding only from the Portuguese government rather than reciprocal partnership arrangements.

3.3. Analysis of Third Countries

3.3.1. Switzerland[141]

Swiss education, research and innovation policy is governed by four-year plans which describe the strategic goals of the innovation system's actors.[142] The plan is bottom-up and decentralised in nature, with the national level policy providing very little thematic steering, focusing rather on the provision of a favourable framework conditions for research and innovation.

The central government (Confederation) and the regional authorities (Cantons) are responsible for research and higher education in Switzerland. The former bears the main responsibility for the direct funding of research as well as for the coordination of research activities. Both actors have an important role to play concerning higher education. The Federal Institutes of Technology (ETH) in Zurich (ETHZ) and in Lausanne (EPFL) are under the auspices of the Confederation and the universities under the Cantons, while federal support to these institutions is regulated by a national act. The Cantons are also responsible for the Universities of Applied Sciences (UAS) based on the framework of national law. The Federal Department of Internal Affairs and the Federal Department of Economic Affairs share the responsibility of research and higher education at the federal level.[143]

Three organisations, consisting of two project funding agencies and an advisory body, operate at the intermediary level. The Swiss National Science Foundation (SNF) supports basic research. SNF is a private foundation that receives its funding from the Confederation. The Swiss Innovation Promotion Agency (CTI) operates at the federal level by promoting public-private-projects as well as other innovation activities. The advisory body - Swiss Science and Technology Council (SSTC) – guides the national government on issues related to science and technology policy.[144]

Regardless of economic downturn, Switzerland is on the right path towards achieving its national R&D investment targets. This is reflected in the GERD (as a share of GDP), which increased from 2.9% in 2004 to 3% in 2008.[145] Swiss education, research and innovation policy is governed by a strategic plan released every four years. It is prepared by the Federal Council and passed by the parliament after a broad consultation process of all potential stakeholders in the course of the so-called "*Vernehmlassungsverfahren*".

The strategic plan for education, research and innovation policy operative between 2008 and 2011 envisaged an annual average growth in public expenditures of 6%.[146] Furthermore, the role of competitive funding of research is emphasised. Implementation of the plan followed in 2008, 2009 and 2010. A series of cuts were implemented in 2011 given the growing financial pressure on public budgets.[147] In addition the economic stabilisation programmes put in place as a counter to the financial crisis yield about EUR 32m of additional spending in terms of support for research and innovation. It is, however, more likely that the economic crisis affects negatively and significantly on R&D expenditures in the private sector.

[141] The summary relies on the ERAWATCH report of 2011, authors: Spyros Arvanitis, Thomas Bolli, Benedetto Lepori and Martin Wörter.

[142] Federal Council, 2007 and 2010.

[143] *Ibid*, p. 11.

[144] Lepori, 2009, cited in Arvanitis et al., op.cit.

[145] *Ibid*, p.2.

[146] Federal Council, 2007.

[147] Federal Council, 2010.

The Swiss BERD in percent of GDP increased from 2.1% in 2004 to 2.2% in 2008, with the comparable EU27 figure being only 1.1% in 2007. Generally speaking, Swiss research and innovation policy aims to foster private R&D investment by improving the framework conditions for research and by promoting technology transfer. Switzerland does not traditionally have direct intervention by the State in private R&D activities. Therefore only a few promotional instruments exist. Furthermore, the major strategic routes in terms of stimulating greater R&D investment in firms that undertake R&D (Route 2), stimulating firms that do not yet undertake R&D (Route 3) and attracting firms from abroad which undertake R&D (Route 4) generally are of limited importance to Swiss research and innovation policy.[148] The main instruments have thus focused on the promotion and establishment of new indigenous R&D-performing firms, increasing extramural R&D carried out in cooperation with the public sector and finally increasing R&D in the public sector.

Switzerland is among the European countries that have been able to provide a very high level of education for their population. Third (33.7%) of the active population had acquired a tertiary education in 2008, which compares well with those with the highest shares among the EU countries.[149] Furthermore, the share of human resources in R&D was 47% in 2009, which again corresponds favourably to the highest EU values.[150] About 45% of these researchers work in the private sector.[151] Expenditures for tertiary education of 1.3% of GDP in 2007 are also comparable to the EU average of 1.1%.[152]

One of the key strengths of the Swiss system is that a large of number of doctoral students graduates from the universities in Switzerland. Considerable amount (1.94%) of the population aged 20 to 29 studies at the PhD level, which is almost double the European average. In this respect Switzerland is one of the top European countries.[153] Furthermore, partly due to the limited number of permanent researchers at the postgraduate level, many of these students at the highest academic level pursues a career in the private economy or in the public administration, thus providing a highly qualified workforce and trained research personnel.

A further reason for a high attractiveness of the Swiss research system is well-functioning labour market for researchers. This has, however, been reflected in a shortage in qualified workers at both public and private sectors during times of economic growth as there is very little reserve. The very low unemployment rate of persons with a tertiary education - only 2.7% in 2009 – also illustrates the good situation for researchers in Switzerland. Simultaneously the average across educational attainments was 4.1%.[154] Furthermore the salary level of persons with a university degree is nearly twice as high as the average Swiss salary.[155]

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148 Lepori, 2009.
149 OECD, 2010.
150 Eurostat, 2010a.
151 FSO, 2010g.
152 OECD, 2010.
153 Eurostat, 2010b.
154 FSO, 2010.
155 European Commission, 2007.

The tertiary level education is also highly international as approximately 50% of the 20,000 doctoral students enrolled in Swiss universities in 2009, came from abroad.[156] The National Science Foundation plays a key role in promoting the education of PhDs as a majority of its personnel (90%) is funded by grants from the SNF. Researcher training, as well as scientific publications constitutes the main outcomes of these projects. Additional investments (about one fifth of the SNF yearly budget) are targeted towards support to doctoral students and researchers in the early stages of their careers.

The measures have evolved over the years and currently encompass all stages of scientific careers below the professorial position:

- Grants for PhD students and postdocs for research stays abroad;
- A range of doctoral programmes (PRO*DOC programme) supporting joint education of PhD students, but also providing grants to the students themselves (with a focus on social sciences and humanities);
- A specific programme funding assistant professorial positions in Swiss universities for a four-year period; these grants are meant to allow the best Post-doctoral researchers to prepare themselves for a professorial position. More recently, a new programme has been launched to support the best Post-doctoral researchers to develop their own research in Switzerland (Ambizione programme).

Policy instrument example: Switzerland

Ambizione Programme

"Ambizione is aimed at qualified researchers from Switzerland who are spending a stay abroad or have returned after a stay abroad, e.g. within a fellowship for advanced researchers. Moreover, Ambizione would like to attract the best, next-generation foreign talents to carry out research work in Switzerland.

Researchers will be subsidised for a maximum of three years with a salary (research associate level) and project funds. The duration of the grant can be extended by a maximum of two years in justifiable cases. Project funds may also be used to employ support personnel. Candidates with sufficient experience may apply to appoint a PhD student with good reason and under specific conditions.

The approval of applications is always dependent on the agreement of the host institute. A requirement for the submission of an application to Ambizione is that confirmation must be received from the host institute, giving the applicant adequate support in the funding of research expenses (e.g. material, equipment, personnel, travel)." [157]

In addition to being able to provide the citizen with excellent opportunities for education and career in the public sector, the Swiss can also claim to have built one of the best research systems in the world, measured by the quality and impact of its scientific production. A bibliometric study of Swiss research, commissioned by the State Secretariat, illustrates the outstanding international level of Swiss science. Consequently Switzerland produces more scientific publications than any other OECD nation - 1.5% of Web of Science publications and 2.5 publications per 1000 habitants, resulting in the highest impact factor worldwide.[158]

[156] FSO, 2010, op.cit, p. 17.
[157] Source: http://www.snf.ch/E/funding/individuals/ambizione/Pages/default.aspx.
[158] SBF, 2007.

The quality of Swiss universities, in comparative European terms, is second to none. The Swiss higher education institutions enjoy good rankings in international comparisons (e.g. Leiden, Shanghai). In the former (based on bibliometrics), three Swiss universities are among the ten best in Europe, while in the latter Swiss Federal Institute of Technology Zurich (ETHZ) is ranked 23rd or the fourth European university, following Oxford, Cambridge and University College London (UCL).[159] Furthermore, four other Swiss universities are among the top 150 institutions in the world.

In addition to researcher quality, researcher availability is also on very high level, both in the internal mobility and outward mobility sense. The Swiss research sector traditionally exhibits a high degree of openness. Hence, the share of foreigners in the private research sector amounts to 32% and the corresponding share in universities is 36%.[160] Similarly, 48% of PhD students were of foreign origin in 2009.[161] Furthermore, the MORE study[162] finds that Switzerland ranks 5th in terms of employment attractiveness after the USA, the UK, Germany and France. Outward mobility is also high as more than 20% of undergraduate students, in 2006, had studied abroad.[163] [164]

Overall, the Swiss system supports the (inward and outward) mobility of researchers that are beginning their careers and allows the recruitment of professors from abroad on a regular basis. The findings of the MORE study[165] confirm the hypothesis, as it ranks the attractiveness of the Swiss system together with France on the third place after the USA and Germany. Mobility in the mid-career stages and joint parallel appointments in France and Switzerland seem, however, to create difficulties related to taxes and social security.[166]

Table 11: Summary: Switzerland

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– The Swiss government has little influence on private research, except in the provision of good framework conditions for the research activities of multinational companies. Hence, research policy focuses on maintaining the quality of the public research sector and the training of skilled researchers.	– High quality of research maintained.	– Attractive employment conditions of Switzerland (in particular wage levels) in combination with a high quality education system, which ensures the availability of human resources and a highly attractive research environment.	– Relatively low level of public spending on research (can also be seen as a strength, depending on the analytical perspective or indicator chosen). – In policy terms: Since most universities are governed by the *cantons*, research is largely decentralised and hence coordination of large infrastructure programmes is relatively complicated. – Tax and social security system.

159 Shanghai Ranking, 2010.
160 FSO, 2010.
161 *Ibid.*
162 European Commission, 2010.
163 FSO, 2010d.
164 *Ibid*, p. 23.
165 European Commission, 2010.
166 *Ibid.*, p. 25.

3.3.2. The USA[167]

Research policy has remained high on the American policy agenda. The governance structure is headed by the Office of Science and Technology Policy (OSTP), which is located in the Executive Office of the President and has a mandate to advise the President and others on the effect of science and technology policy on domestic and international affairs. The OSTP also acts as an inter-agency coordinating body. The Executive Branch of the government includes 12 federal departments and 18 federal agencies that fund research. This funding is provided by the US Congress through authorisation and appropriation legislation.

The USA invested EUR 270.7b ($398.1b) in R&D in 2008. The private sector plays a key role in funding (nearly two-thirds) and undertaking (more than 70%) R&D. The GERD (in US dollars) has been on the rise recently, growing more than 14% from 2006 to 2008, and exceeding the rate of the larger economy (i.e., GDP) during the same time period. Government funds more than one-fourth of R&D in the USA. The government-funded public research organisations, however, conduct only 4% of all R&D work. Furthermore higher educational institutions perform most of the remainder.[168]

The profile of the American research environment is second to none. It has historically been, and remains, one of meritocracy and excellence, where competition and incentives provide a significant driver. The USA has long been a relatively attractive destination for researchers. Its share of foreign students has experienced occasional declines since the post-9/11 security concerns emerged. At the same time, however, the USA continues to be the most frequent location for undergraduate and graduate students, with nearly 600,000 foreign tertiary education students. More than 20% of the USA's doctoral students are from outside the country. The share of foreign postdoctoral students is much higher (57%). It is estimated that foreign-born college degree holders account for one-fourth of the science and engineering employees in non-academic positions but about half of engineering, mathematics and computer science workers. More than 40% of foreign-born workers in science and engineering received their highest degree from a US university, more than half went to a university outside the USA at some point in their academic career. 37% of all doctoral degrees were granted to non-US citizens.[169]

American policies to increase public support for research have been reinforced by the re-authorisation (in 2011) of the America COMPETES Act. Research support policies, which are built on a continued emphasis on quality and competition (through the USA peer–review system), consistently highly-ranked American universities and good access to world-class research infrastructures. In addition, mobilising research to address societal challenges, particularly in the energy area, has become more important in the US system under the current administration. Programmes to support the societal response to scientific research are evidenced in small but important initiatives that are part of the National Nanotechnology Initiative. Research capacity questions concerning the distribution of federal R&D investments are addressed in a few programmes such as EPSCoR, but are very small in relation to the main focus topics. Questions about human capital capacities are raised occasionally in debates about visa limits and processes.[170]

Policy instruments have been targeted in particular on areas of particular interest, such as energy research, as highlighted by the example of Experimental Program to Stimulate Competitive Research in the energy sector.

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[167] The summary relies on the ERAWATCH report of 2010, author: Jan Youtie.

[168] ERAWATCH Country Reports 2010: United States of America, p. 3.

[169] Source: National Science Board, Science and Engineering Indicators 2010, cited in Youtie, op.cit.

[170] *Ibid*, p. 5.

Policy instrument example: the USA

***Experimental Program to Stimulate Competitive Research* (EPSCoR)**[171]

The American Department of Energy (DOE) maintains EPSCoR, which is located in the Office of Science. The programme assists the Office of Science by supporting basic and applied research and development across a wide range of interdisciplinary areas, such as Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics and Nuclear Physics. It also supports research that is relevant to other DOE Programme Offices. The participation of these other programmes is critical to the success of EPSCoR applications and developing an understanding of these programmes has been set as a long-term objective of all EPSCoR applicants.

The programme goals are as follows: a) improving the capability of designated states and territories to conduct sustainable and nationally competitive energy-related research; b) jumpstarting infrastructure development in designated states and territories through increased human and technical resources, training scientists and engineers in energy-related areas; and c) building beneficial relationships between scientists and engineers in the designated states and territories with the 10 world-class laboratories managed by the Office of Science, leverage DOE national user facilities, and take advantage of opportunities for intellectual collaboration across the DOE system. Funding Opportunity Announcements (FOAs) are posted to applicants every one to two years. The annual budget is approximately $8 million per year.

EPSCoR is a science-driven, merit-based programme that supports basic and applied research activities spanning the broad range of science and technology programmes within the DOE's range of activities. The programme also places high priority on increasing the number of scientists and engineers in energy-related areas. The programme places particular emphasis on collaboration between young faculty, postdoctoral associates, graduate and undergraduate students and scientists from the DOE national laboratories where unique scientific and technical capabilities are present, and, in so doing it also supports the emergence of top research from more junior ranks. Applications are assessed in a traditional peer review process, thereby ensuring the consistency of high quality.

Most academic professionals and staff are employees of the State university system, if they are with public universities, or employees of private universities. Temporary contracts and fellowships are subject to tax. The US educational data reporting system and public research reporting system does not provide public information on the permanent positions occupied by foreigners.

The availability of visas for foreign researchers has been a cause for concern. A multitude of visas allowing temporary work in the USA exist. For instance the J-1 exchange visa grants a permit for summer or semester-length stays at a university in the USA. H-1B visas, on the other hand, permit three-year stays in the USA as well as an option for additional three-years. It is common that the visas are granted to highly-skilled workers. The amount of H-1B visas has, however, decreased considerably due to the increased emphasis on homeland security in the early 2000s. The situation has gradually changed. First the universities and other academic institutions were given a permission allowing exemptions concerning students and temporary academic personnel.

[171] Text taken from http://science.energy.gov/bes/epscor/about/ (Accessed: 20 April 2012).

Another improvement took place during the mid-2000s as further exemptions were granted to Master's or doctoral degree personnel if graduating from American universities.[172]

The USA has established bilateral contracts and so-called 'Umbrella Science and Technology Agreements' with several European countries, namely Bulgaria, Croatia, Finland, Greece, Italy, Romania, Slovakia, Slovenia, and Spain. These one-to-one contracts lay foundation for science and technology cooperation, intellectual property protection, research access and other related topics. The bilateral agreements are fastened with policy dialogue and joint activities on the European level. The Scientific and Technological Co-operation Agreement between the European Union and the United States date back to 1998. A renewal of the contract followed in 2004 to allow broader framework for collaboration in a number of scientific areas. There are additional agreements targeting strategic research on fields such as fusion energy and environmental research. [173]

Exchanges between the USA and Europe are among the most prominent cooperative research activities. One of the best known exchanges is the Fulbright Program that was created after World War II in the Fulbright Act of 1946 (Public Law 584). The program aims to support international exchanges between Europe and the USA by sponsoring scholarships. These grants are an insurance for the travels of research and teaching personnel to and from the USA at all academic, as well as faculty and administrative levels. The extension of the programme included a wider range of funding sources in 1961. The programme currently covers more than 155 countries.[174]

During the FP6 programme period, three out of four of the 303 European researchers who benefited from Marie Curie Outgoing International Fellowships (OIF) went to the USA (228 researchers in total).[175]

Table 12: Summary: USA

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– The America COMPETES Act of 2007 (Public Law 110–69.), which aims at doubling the research budgets of three federal agencies and institutes to enable breakthrough energy-related research. – The National Nanotechnology Initiative. – Experimental Programme to Stimulate Competitive Research (EPSCoR) programme. The NSF's Major Research Instrumentation Programme, which includes the CISE Computing Research Infrastructure.	– Attractive employment and working conditions.	– Still globally the most attractive research environment, positive cycle of top scientists attracting more top scientists. – Research infrastructure further developed in selected priority areas such as nanotechnology and energy.	– Large and fragmented research infrastructure and higher education system, which can sometimes lead to differences in standards. – More restrictive visa policies and their impact on inward mobility.

[172] Source: National Science Board, Science and Engineering Indicators 2010.

[173] Source: Pals S., Wang, T. (2010), cited in ERAWATCH Country Reports 2010: United States of America, p. 31-32.

[174] Source: US Department of State, Fulbright Program.

[175] Source: European Commission FP6 database of contracts.

3.3.3. Brazil[176]

The main government body responsible for research and innovation policy is the Ministry of Science, Technology and Innovation (MCTI).[177] Brazil has consistently increased its investments in R&D in recent years. The overall investment in S&T have risen from 1.28% of GDP in 2006 to 1.63% in 2010. The target set for the year 2022 is 2.2%. According to the latest available data the R&D intensity (GERD/GDP) was 1.63%, the share of private sector R&D (of GERD) accounted for 45.25% while the share of public sector (federal and state) R&D (of GERD) was 54.75% in 2009. The BERD decreased slightly from 0.62% of GDP in 2006 compared to the 2010 estimate of 0.56%, thus not reaching the PACTI target of 0.65%.[178]

In Brazil, there are 0.92 researchers for every 1,000 workers, which is low compared to well-established G7 economies with typically around 6-8 researchers per thousand, but this figure is entirely comparable with other large, growing research bases such as China. Brazil also produces over 500,000 new graduates and about 10,000 new PhD researchers each year, a similar number to France and South Korea. This represents a ten-fold increase in twenty years: Brazil's skilled research workforce is clearly on the increase.[179]

Collaborative linkages are also on the increase. Brazil has a strong profile in life sciences in particular and is emerging as a key global player in two areas of critical importance to the health of its population: tropical medicine and parasitology. In these areas, its authors or co-authors represent a high percentage (in both cases more than 1 paper in 10) of the world's scientific publications.[180] International collaboration is highly active. The apparent lack of linguistic ties is striking: there are no other institutions in countries in which Portuguese is spoken among the top-10 collaborative research institutions as they are dominated by the USA, France and Italy, with even Sweden appearing in 10th place.[181]

Increasing focus has also been placed on developing a world-class research infrastructure, e.g. increased funding for the research infrastructure and support for national research institutes, as well as enhancements to the high-speed network for research purposes. The latest PACTI discussions referred to the development of "multi-user national labs".[182] In the 2007-2010 PACTI programme, which aimed at the expansion and consolidation of international cooperation, one of the priority areas concerned structuring and expanding initiatives that promote high-level scientific and technological cooperation with developed nations, including European countries. One of the aims here is to increase and strengthen bilateral cooperation, notably with the European Union countries, the United States, China and the Ukraine.

[176] The summary relies on the ERAWATCH report of 2010, author: Antonio José J. Botelho PhD.

[177] Until 2011 known as the Ministry of Science and Technology (MCT).

[178] Botelho (2011), p. 11.

[179] Adams & King 2009, Global Research Report, Brazil, p. 4.

[180] *Ibid*, p. 12.

[181] *Ibid*, p. 12.

[182] Botelho 2010, p. 6.

The new strategy for science, technology and innovation was drafted in 2011, with the goal of increasing R&D&I investment through the building and strengthening of critical competencies in the national economy, enhancing productivity and technology within value chains, expanding the domestic and external markets of Brazilian companies, and ensuring socially inclusive and environmentally sustainable growth. Here also research grants are introduced to attract international researchers. A total of 101,000 grants are to be awarded during the period 2011-2015, 26,000 of which are to be provided by the private sector.[183]

Brazil has, through the National Council for Scientific and Technological Development (CNPq)[184], entered into several bilateral agreements with many foreign agencies and organisations in a number of European countries. Most of them are umbrella scientific cooperation agreements with national research agencies often covering the exchange of personnel and joint scientific research projects with their counterparts in the European countries (for instance DAAD in Germany, CNR in Italy and FCT in Portugal). Other agreements have a more disciplinary focus given that the partner is a national technical research institutes or similar.

During the past few years the development of bilateral cooperation in science, technology and innovation has been significant, especially with the ERA countries. Although the cooperation between Brazil and Germany dates back to a general agreement from 1969, it has been expanded over the years to encompass for instance genomics and nanotechnology.[185] Currently funds worth of R$20m (EUR 14.0m) are provided for these cooperation programmes by the MCTI and its agencies.. The largest share has been allocated for the Amazon High Tower Observatory programme. There are also other thematic research programmes organised jointly with Germany. They focus on manufacturing technology, marine sciences and water resource mitigation in the North-East of the country.[186]

Table 13: Summary: Brazil

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– The 2012-2015 strategy addresses the need to attract young researchers and internationally recognised research leaders to Brazil.	– Individual attractiveness factors, grants for researchers.	– Numerous international bi-lateral cooperation agreements, Brazil being an attractive partner. – Increased volume of research and possibility of establishing new research groups. – Working conditions and employment security, with federal and state researchers and university professors having guaranteed employment stability.	– First funded networks become closed networks and hamper development of emerging groups, established research groups become complacent. – Accreditation system making the entry to the HEIs complicated for foreign nationals. – Potential threats of protectionism (reflected in the lack of explicit RDI measures addressing attractiveness).

[183] MCTI 2011. See also: http://www.brasilmaior.mdic.gov.br/wp-content/uploads/2011/10/apresentacao_pbm_eng_rev_outubro2011.pdf.

[184] For more information, see: http://www.cnpq.br/.

[185] *Ibid.* 33.

[186] Op. Cit..

3.3.4. India[187]

The level of gross expenditure on R&D remains low in India, not only compared with the leading economies in the world but also with other emerging economies. Implementing the research policy commitments of spending 2% of GDP on R&D and almost 6% of GDP on education remain the grand challenges for India. The current levels are 1% and around 4.4% respectively.[188]

The Indian governance system for research and innovation is built around the Science & Technology International Cooperation Division of the Ministry of Science and Technology.

The tasks of this organ encompass international scientific and technological affairs that consist of negotiating and implementing the Scientific and Technological Cooperation Agreements. Furthermore it is responsible for scientific and technological aspects of activities of international organisations. Bilateral, multilateral or regional frameworks represent a platform most often utilised to support closer interaction between governments, academia, institutions and industries in areas of mutual interest.[189] India has established International Cooperation in S&T with some 45 countries around the world.

The EU encourages the free flow of European citizens without the need for strict visa conditions. There is no such arrangement within SAARC (South Asian Association for Regional Development) and only people from Nepal and India have free mutual mobility. Generally, Indians need to obtain visa permits for all countries in the world. There are work visas known as H1B[190] visas given to Indian software professionals in the USA and some work related permits in EU region.

In terms of research collaboration with Europe, there are a number of collaborative efforts and programmes that India is involved in, such as outlined in the ERAWATCH report:

- "The International Thermonuclear Experimental Reactor (ITER) nuclear fusion energy project;
- The satellite based navigation system, Galileo Project (European version of the USA's Global Positioning System);
- Participation member in FP7 Framework Programmes for 2007-13;
- Joint scientific projects, including those in strategic fields, after holding the first ministerial science conference between the EU and India in New Delhi in February 2007.
- Euro-India ICT co-operation Initiative (EuroIndia SPIRIT) was a 2-year (2009-2011) EU-funded project aimed at addressing strategic goals to identify and sustain EU and Indian Research & Technology Development (RTD) potential. The key objectives of the initiative included the mapping of ICT research and innovation activities across India and a survey of the Indian ICT R&D players, which will be supported by Information Days and Technology Brainstorming events across India;[191]
- Nanotechnology for developing new materials, an initiative launched in 2007[192];

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187 The summary relies on the ERAWATCH report of 2011, author: Dr V. V.Krishna.

188 *Ibid*, p. 3.

189 ERAWATCH Report 2011, p. 27.

190 These are non-immigrant visas in the United States under the Immigration and Nationality Act, section 101(a)(15)(H). This allows U.S. employers to temporarily employ foreign workers in specialist occupations.

191 Euro-India SPIRIT (http://www.euroindia-ict.org/); ERAWATCH Country ages: India: (http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/in).

192 *Ibid.*

- India has also signed a cooperation contract with the EU to participate in the proposed Facility for-Antiproton-and-Ion-Research (FAIR) project aimed at understanding the tiniest particles in the universe.;
- Indian S&T international cooperation has a budget of over 48 million Euros. A considerable share of this budget is being spent on the EU-related programme in S&T."[193]

Table 14: Summary: India

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– Bilateral agreements as described above.	– Quality issues within the research environment and infrastructure, with The National Assessment and Accreditation Council (NAAC) stressing the need for quality assurance as an integral part of the functioning of any higher education institution.[194]	– Presence of many multinationals with their R&D making India potentially attractive as a knowledge-based location. – 250 global firms (most of which are *Fortune 500* companies) have set up their R&D centres/laboratories and units in Hyderabad, Bangalore, Delhi, Gurgoan, Pune and Noida. – High population potential, though currently with very low level of education and high drop-out rates.	– Limits on enhancing the research capacity relating to the weak level of organisational and institutional capacity. – Poor working conditions and obsolete scientific instrumentation in many institutions due to budgetary limitations. – Expanding universities in quantity at the cost of quality and excellence, Humboldtian goal of increasing research intensity in universities is progressing very slowly. – Business driven, not research driven model vulnerable to international business fluctuations.

[193] *Ibid*, 28.

[194] NAAC's mission is to arrange for the periodic assessment and accreditation of institutions of higher education or units thereof, or specific academic programme or projects; to stimulate the academic environment for the promotion of quality in terms of teaching, learning and research in higher education institutions; to encourage self-evaluation, accountability, autonomy and innovations in higher education; to undertake quality-related research studies, consultancy and training programme; and to collaborate with other higher education stakeholders in terms of quality evaluation, promotion and sustenance. (Ibid).

3.3.5. China[195]

In 2009, China's Gross Domestic Expenditure on R&D (GERD) reached its highest peak in recent years: EUR 58,021 million. Despite the impressive figure, the total R&D investments in relative terms and the level of R&D intensity still lag behind those of the advanced economies. For instance the GERD *per capita* for China (EUR 43.3 in 2009), corresponds only to 9% of the EU-27 average (EUR 476.2). Comparison with the USA (EUR 889.1) drops the figure to mere 5%. The business sector contributes considerably to R&D funding (72%) while the government is responsible for 23%. In terms of R&D expenditure allocated, the main consumers of this funding were research institutes and universities (with 82% share).[196]

The central government organises as well as controls the highly centralised research system in China. Three parts constitute the structure in an administrative hierarchy: the main decision-making body representing the central government level (the State Council, and the National Steering Group for S&T and Education in particular), the agencies coordinating and implementing research (such as the Ministry of Science and Technology, the Chinese Academy of Sciences, the Ministry of Education, and other ministries and agencies), as well as R&D-performing institutions (universities, research institutes, and enterprises).[197]

Recently China has designed and implemented programmes and projects such as the "Hired Foreign Research Fellows" programme and the "Youth Foreign Scientist Project" to attract skilled individuals from abroad. The Chinese Academy of Sciences has been responsible for both since 2009.

The former is aimed at recruiting foreign associate professors, while the latter at newly graduated PhDs to work in China. The programme and the project have supported 477 professors and 179 Post-doctoral researchers by 2011. Permanent residence or multiple-entry visas have also been put in place to facilitate the work/residence permit process for foreign researchers. The visas are for non-Chinese professionals and their families and they are valid for a period of two to five years.[198]

The following three non-governmental organisations operating under the auspices of the Ministry of Education are the most important actors in terms of international educational exchanges: The China Education Association for International Exchange (CEAIE), China Scholarship Council (CSC) and Chinese Service Centre for Scholarly Exchange (CSCSE).[199]

Efforts are underway to intensify scientific collaboration activities between China and the European countries, and accumulated evidence suggest that Chinese policy-makers value EU-China bilateral cooperation and view this as an opportunity to strengthen scientific, economic, and political relationships with these European countries.[200]

In addition, a variety of bilateral and multilateral cooperation agreements and programmes with scientifically advanced economies have been set up to stimulate knowledge transfer across national borders, such as the Sino-US S&T Agreement, the China-U.S. Physics Examination and Application (CUSPEA) program, the Joint Fund on Major Scientific Equipment Research, and the EU-China Framework Programs, to name but a few, have been established in recent decades.[201]

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195 The summary relies on the ERAWATCH report of 2010, author: Li Tang.

196 *Ibid*, p. 14.

197 *Ibid.*, p. 15.

198 Source: SciDevNet, http://www.scidev.net/en/news/china-on-the-look-out-for-foreign-scientists.html, (Accessed: 8 May 2012).

199 Source: Erawatch, http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/country?section=NationalPolicyDevAndEuropeanResearchArea&subsection=LabourMarketForResearchers.

200 *Ibid.*

201 ERAWATCH COUNTRY REPORTS 2010: Russian Federation, p. 32.

Table 15: Summary: China

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– 'One Thousand Talents Scheme', a nationwide programme building on the experiences of the previous 'One Hundred Talents Programme', with the goal of bringing approximately 2000 academics back to China over the next 5 to 10 years. – At the same time the Chinese government has strengthened international cooperation with developed counties via information sharing, personnel exchange, as well as joint research projects.	– Infrastructure and personal level incentives, Developing world-class research institutions both through infrastructure and quality, but importantly with the help of establishing innovation centres, creating model courses in notable colleges and universities, and gathering groups of first class talent from around the world.	– Both national and regional governments have maintained the rising trend of R&D investment in recent decades. – China has successfully attracted hundreds of top academic and industrial leaders of Chinese descent to return to China. – The "sending out, attracting back" policy facilitates knowledge circulation between China and the advanced economies.	– Still difficulties in maintaining the international talent in mainland China. – The chosen "picking-the-winner-approach" worsens resource equality among Chinese elite universities and the rest of the country, thereby accentuating the existing lack of transparency in the system.

3.3.6. Russia[202]

The main actor in the governance structure for Russian research and innovation policy is the Ministry of Education and Science (MES). The Governmental Commission on High Technologies and Innovations is responsible for the coordination of research policy at the governmental level. Research-related advisory bodies reporting to the President include the Council for Science, Technologies and Education and the Commission for the Modernisation and Technological Development of the Russian Economy, the latter dealing especially with innovation-related matters. Within the Russian Parliament, two committees take care of research policy: in the lower house, the State *Duma*, the Committee on Science and High Technologies, and in the upper house, the Federal Council, the Committee on Education and Science. Both committees have a mandate to propose and scrutinise legislation relevant to R&D issues.[203]

Over the years, Russia has experienced an outflow of researchers as a result of the post-soviet economic hardships caused by sharp reductions in investment in the R&D sector. In particular during the 1990s, researchers emigrated abroad, especially to the USA and the EU Member States. Currently, outward mobility for researchers is supported at low level scale by the Russian Foundation for Basic Research (RFFI) for seminar participation and for the research stays of young scientists abroad. A new programme launched by the Ministry for Education and Science at the end of 2010 is the "Presidential Stipends for students and PhD students"[204]; the first call for this programme closed in April 2011. Another round of stipends was announced in 2012.[205]

[202] The summary relies on the ERAWATCH report of 2010, author: Manfred Spiesberger and the additional data compiled by Daria Zimina.

[203] *Ibid*, p. 14-15.

[204] http://mon.gov.ru/files/materials/8176/10.12.30-stipend.pdf.

[205] *Ibid*.

The scientific 'diaspora' has however been addressed through policy measures with wage levels also being increased to some extent. There have also been plans for "Megascience" projects for national infrastructure projects, which may also be relevant in the desire to attract top scientists, but as they are predominantly infrastructure-based are not directly relevant for the purposes of the study presented here.

Inward mobility to Russia for permanent research and academic positions has been very limited. A certain paradigm shift can however be observed recently in Russia in terms of the opening up of the national R&D and innovation system and towards inward mobility accordingly. Two specific funding activities have been launched by the Ministry of Education and Science: The first funding activity is aimed at Russian scientists who work abroad (the scientific diaspora), to incite them to work in cooperation with Russian research groups. Two calls for the support scheme have been launched in 2009 and 2010 respectively under the framework of the Federal Targeted Programme Scientific and Scientific-Pedagogical Personnel of Innovative Russia for the years 2009-2013. The first call provided support for 110 projects while the second for 125 projects.

The objective of the second support scheme has been to encourage leading scientists from Russia and especially from abroad (irrespective of whether they belong to the Russian scientific diaspora), to establish research groups at Russian universities. The scheme requires the chosen scientists to spend at least four months per year in Russia to be eligible for support. This scheme provides each project with solid funding of approximately EUR 3.5 million for a period of usually two to four years. The first call resulted in the selection of 40 scientists, who received support for their projects. The requirements (half of the researchers in a team must be foreign nationals) were fulfilled, although only five scientists lived permanently in Russia.

The most common country of origin were the USA (ten scientists - with four having double Russian and American nationality), followed by Germany (seven scientists). The participation of foreign experts in the evaluation process of the proposals can be seen as a significant step in the right direction towards 'transparency' in the Russian R&D and innovation sector. A second call in the scheme was launched in April 2011, and the results were published in autumn 2011.

The mobility of researchers between the EU and Russia is however still hampered by, among other things, language barriers, the generally harsh living conditions experienced in Russia, administrative hurdles and cumbersome visa procedures.[206] An EU-Russia visa facilitation agreement became effective in 2007 as a response to the challenges faced with visa.[207] The improvements in the scheme consist of guidance for cost-free visas and an administratively simplified visa application procedure for participants in scientific exchange programmes. The implementation of the agreement has, however, been slow and it has not yet reached the set objectives.[208]

206 http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/country?section=NationalPolicyDevAndEuropeanResearchArea&subsection=LabourMarketForResearchers.

207 http://eeas.europa.eu/delegations/russia/travel_eu/visa/index_en.htm.

208 http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/country?section=NationalPolicyDevAndEuropeanResearchArea&subsection=LabourMarketForResearchers.

Policy instrument examples: Russia[209]

Research grants for international researchers coming to Russia for instance include **Presidential Stipends** among the examples of individual level policy measures. These stipends have been established in order to provide support to young (under 35) scientists and postgraduates engaged in promising research and development in key economic modernisation fields. The stipends will be paid for a three-year period, can be awarded to an individual more than once, and will come to a total of 20,000 roubles [$700] a month. A maximum number of 500 people will receive the stipends in 2012, but starting in 2013, the maximum number will be doubled to 1,000.[210]

Grants addressing Russian HEIs can also be seen as an instrument to attract international researchers, as the collaboration of academics is not restricted by nationality or citizenship. Funding worth of EUR 300m has been reserved for the period 2010-2013. A higher education institution (HEI) can receive an individual grants amounting to EUR 3.75m at the maximum. The Principal Investigators manage the funds, although HEIs are the actual recipients of the grants. A call for participation has taken place in 2010 and 2011. New calls are not foreseen. The calls received plenty of applications - 507 from academics and 179 from HEIs in 2010 and 517 and 176 the following year. The approval rate remained rather low in both years as 40 projects became chosen in 2010 and 39 in 2011. International expertise has been the cornerstone of the selection process.

The grants belong to a larger initiative designed to support the activities in most competitive universities to: 1) increase the quality of education, 2) develop world class research centres, and 3) create strong links with the innovative economy chain. The motion consists of the following measures: support for the Moscow State University and the St. Petersburg State University development programmes, creation of the National Research universities, modernisation of the innovative infrastructure of the federal universities, development of cooperation between Russian universities and industrial enterprises and the development of the innovative infrastructure in Russian universities.[211]

The most relevant cooperation framework in research terms between the EU and Russia is currently the concept of the four common spaces, one of which is research and education.[212] Research cooperation is governed by the EU-Russia Science and Technology Cooperation Agreement, which was renewed for a further five-year period in 2009.[213] Regarding research, these measures concern for example the identification of thematic priorities for cooperation and facilitation of the participation of Russian teams in the 7th EU Framework Programme for Research and Development (FP7).[214]

The EU and Russia agreed on a Science and Technology contract in 1999, which was renewed in 2003 and again in 2009.[215] This agreement legally supports the participation of

[209] Source: Erawatch country pages: Russia: (http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/supportmeasure/support_0011?tab=template&avan_type=support&country=ru).

[210] http://www.eng.kremlin.ru/news/3426.

[211] *Ibid.*

[212] http://eeas.europa.eu/russia/common_spaces/index_en.htm.

[213] EU-Russia Common Spaces Progress Report 2010.

[214] Erawatch Country pages: Russia (http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/country?section=InternationalisationOfSTCooperation&subsection=Instruments).

[215] Erawatch Country pages: Russia (http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/ru/country?section=InternationalisationOfSTCooperation&subsection=Instruments).

Russian scientists in the FP as well as their cooperation in other European initiatives such as COST and EUREKA.[216]

Starting from 2001, EURATOM (covering both fission and fusion) has also been included in S&T agreements. The formalised process of S&T cooperation is intended to be included in a new framework agreement concerning cooperation between the EU and Russia. Negotiations on this agreement were concluded in 2012.

Russia also has a number of bilateral Science and Technology agreements with several countries in the EU as well as in associated countries. Russia has engaged in an extensive cooperation with countries such as France, Italy and Germany, ranging from mobility schemes to funding of joint research projects and co-funding allocated to research infrastructures from joint laboratories. In addition, smaller EU countries such as Austria, Finland and Greece and other FP7 associated countries such as Israel, Norway and Switzerland have substantial ongoing cooperation on a bilateral level with Russia and have established joint mobility and research funding schemes.[217]

Table 16: Summary: Russia

Main policy instrument for attracting top scientists	Attractiveness factors mainly addressed:	Strengths / Opportunities	Weaknesses / Threats
– Support tools for enhancing research within universities introduced since 2009. – *Innovative Russia - Strategy 2020* was published in 2011.[218]	– Individual level, though with a more general approach of addressing the brain drain rather than attracting top scientists as such.	– Increasing network of international cooperation programmes available. – Considerable international interest in programme for attracting leading scientists (mainly from abroad) to Russian universities.	– Despite the history of valuing high education, low salaries, limited career perspectives and outdated equipment deter young talents from embarking on a scientific career and lead them to the business sector for better paid job options. – Low productivity and output in certain research institutions and ageing of the R&D personnel due to migration. – Perceived bureaucratic burden (for international recruitments). – Comparisons difficult as output verifications problematic and not implemented across the country and its HEIs. – Related issue of qualifications not always meeting the requirements of the labour market and of research. – Co-funding cannot always be attracted to the extent initially planned in certain programmes.

[216] COST is an intergovernmental framework for European Cooperation in Science and Technology, allowing the coordination of nationally-funded research on a European level (see: http://www.cost.eu/). EUREKA is an intergovernmental network that seeks to promote international, market-oriented research and innovation through the support offered to small and medium-sized enterprises, large industry, universities and research institutes. (see: http://www.eurekanetwork.org/about).

[217] Source: ERAWATCH report 2010, p. 37.

[218] http://www.economy.gov.ru/wps/wcm/connect/economylib4/en/home/activity/sections/innovations.

4. POLICY GAP ANALYSIS: STRENGTHS AND WEAKNESSES IN RELATION TO THE ATTRACTION OF TOP SCIENTISTS

Having identified the main characteristics of the policy framework at the EU level and at the national level for the selected countries featured in this study (Chapter 3), we move onto examining how such characteristics effectively promote the attractiveness of EU countries for top scientists as compared to other competing countries (section 4.1). At this level, attention is placed on national policies that are currently applied. The reason is that while national policies are influenced to a varying degree by those employed at the EU level, European countries still exhibit considerable differences in terms of their level of resources and R&D capacity. Consequently, the effect of policies on the attractiveness of top scientists can only be assessed at a national level.

The subsequent steps are to determine the strengths (section 4.2) and the weaknesses (section 4.3) in relation to the attraction of top scientists. These national-level factors are however related to the structural issues that would perhaps be more efficiently addressed at the European level.

4.1. Current national policies *vs.* Attractiveness Factors

An overview of the national policy analysis is provided in table 17 below. The related policies in most countries aim at enhancing the quality and productivity of the national Research and Innovation systems. The strongest countries (e.g. Germany, Finland) and some new Member States such as Estonia have well functioning research infrastructures and frameworks for promoting high quality research. There are however few initiatives targeted specifically at scientific excellence and accompanied by corresponding incentives with a view to attracting top scientists.

In some cases, even the strong European countries still lag behind in terms of financial incentives, while in other cases the taxation level remains a challenge. The main gaps are generally to be found in the wage levels offered by competing countries. At the same time, insufficient flexibility exists in the system to attract and recruit the younger talents that would create density and a critical mass around world-leading research endeavours.

The mobility measures on the EU level have thus received a varying degree of attention and, as shown in Chapter 3, most EU Member States still employ a bilateral approach or rely on quite traditional grant mechanisms to attract researchers.

The field is clearly on the move and there are significant trends that suggest that the global research geography will be significantly altered in the years to come. In the BRIC countries and particularly in Brazil, China and India, the most striking feature of the new geography of science is the sheer scale of investment and the mobilisation of people behind innovation that is underway, driven by a high-tech vision of competing in the global economy.[219] The ability to attract Foreign Direct Investment does not necessarily go hand in hand with the attraction of top international scientists, but the level of interest shown by international investors may be raised if improvements are made to the research infrastructure and to the overall research capacity of the country in question. As a 'knock-on' effect this may also help to convince top scientists to relocate thus forming something of a virtuous feedback loop between FDI and the attraction of top scientific expertise.

[219] Adams & King 2009, Global Research Report, Brazil, p. 4.

Table 17: Summary of strategies and attractiveness factors addressed across countries analysed

Strategy and policy tools	Attractiveness factors mainly addressed	Strengths	Weaknesses
EUROPEAN COUNTRIES ANALYSED			
- In most EU countries an innovation strategy or national policy guidelines exist to promote the attractiveness of the national research environments. - There is a trend in the new Member States to draft national innovation or research strategies to address the bottlenecks in national research environments (e.g. Bulgaria and Estonia). - Policy instruments designed to attract top scientists, encourage the return of national researchers and for the recruitment of excellence do exist (FiDiPro in Finland and Alexander von Humboldt professorship in Germany for instance).	- In most countries R&D&I policies are directed towards building a modern research and development infrastructure. - The most developed R&D&I countries seek to address the personal factors and make better use of quality of life issues, as well as easing possible administrative bottlenecks and quality of the research environment (people, facilities and resources). - New Member States seek to address the institutional factors, with a focus on "repatriation programmes " and bilateral cooperation. - Specific programmes exist that address the environment for high-tech entrepreneurship (e.g. Estonia). - More motivating remuneration and more attractive conditions for Doctoral studies as the first step in promoting attractive research environments, addressing the entry and working conditions, as well as career options and tenure track issues (across the EU).	- High public and private R&D expenditure in the most developed countries. - Internationalisation addressed in an explicit fashion in governmental programmes and main policy instruments of the last 5 years (e.g. Germany, Finland, Portugal). - Attractive in some research areas with high specialisation. - Good brand and quality of life issues that could be promoted more actively (safety, security, childcare, basic education etc., in the case of Finland for instance). - A large expatriate community potentially at the disposal of the national policy (e.g. Greece, Italy, Portugal). - Attractive working conditions and high wage levels in a few cases (notably Germany). - Virtuous cycle: as attracting top scientists is a long, path-dependent process, those who have invested in R&D and attracting top talent need to work considerably less than those trying to catch up.	- Brain drain caused by financing and wage level. - Lack of tenure track systems ➔ Consequence: Lack of competent high-skilled labour. - Budgetary cuts in national R&D spending. - High level of taxation. - Some cases of language policy restricting attractiveness (Greece, also Germany to some extent). - Risk of a potentially severe vicious cycle: those that are lagging face increasing challenges in catching up due to the preconditions of economic austerity. - When there is less resource available for the development of basic infrastructure, even less is available for achieving the competitive advantage required in global competition (though opposite examples also exist of important catch up, e.g. Estonia and Portugal).

Table 17: Summary of strategies and attractiveness factors addressed across countries analysed (continued)

Strategy and policy tools	Attractiveness factors mainly addressed	Strengths	Weaknesses
THIRD COUNTRIES			
- Mainly bilateral contracts. - No specific policies. - Exceptions are in: - USA: "American Competes" legislation and "EPSCoR" Programme, - China: The "sending out, attracting back" policy, One Thousand Talents Scheme), - Russia: "Innovative Russia" Programme.	- Infrastructure and personal level incentives. - Developing world-class research institutions both through infrastructure and improving quality.	- Wage level (USA and Switzerland). - Competing packages to international top scientists for short/long-term stays, combined with stimulating repatriation programmes (e.g. China). - Large scale investments in science and technology as a means to compete on the international stage. - Positive working conditions, and employment security (e.g. Brazil). - Low level of administrative burden. - Possibility to build research groups and teams in competitive environments on the conditions requested by the top researchers (e.g. USA, Switzerland, also to some extent the BRICs, notably Brazil and China). - High number of multinational companies and FDI (India and China).	- Visa policies sometimes restrictive (the USA in particular). - Accreditation system (Brazil) making the entry to the HEIs complicated for foreign nationals. - Being more business driven, potentially also more vulnerable to economic fluctuations (India). - "Picking the winners" leading to large disparities within a country (China).

4.2. EU Strengths in attracting top scientists

In terms of research environments, the traditional unit of analysis has mostly been that of the individual state though in some cases the discussion of more localised and micro units has also emerged onto the research agenda (e.g. urban centres or other regional constellations in a territorial sense, more localised research environments within universities or research institutes etc). In this study, we have focused our attention on the national level and national policies, while also paying heed to the fact that in some cases different units and localities have varying levels of capacity to actually make use of national or European policies and thus, in such cases, a micro level analysis may actually be more fruitful in order to properly discern such dynamics.[220]

Our analysis has shown that the most important attractiveness factor for top scientists is the one related to the research environment and its focus on excellence. The EU exhibits significant potential in terms of skills and infrastructure thus offering a basis for such centres of excellence to be developed in a variety of sectors and disciplines. As such, this may lead one to conclude that more focus and specialisation might be needed, requiring stronger links and greater coordination between European, national and regional strategies.

One such opportunity could be offered through the notion of 'smart specialisation'.[221] The upcoming programming period[222] is designed to focus effort and attention on both R&D&I and European Structural Funds-driven regional policies on innovation, smart growth and smart specialisation. The strategies foreseen for this purpose seek to ensure a more effective use of public funds, while at the same time stimulating private investment. They can also help regions to concentrate resources on a selected few key priorities rather than spreading investment thinly across many areas of the business sector. They can also be a key element in developing multi-level governance for integrated innovation policies, where all levels of policy innovation, planning and implementation are used in the role best suited for them.

Numerous actions have already been taken in this regard to promote a better integrated policy mix while seeking also to find an appropriate role for each governance level. The European level has for instance already facilitated the formulation and implementation of smart specialisation strategies by national and regional governments and more could be done in order to identify the actions and measures that could be most effective here.[223]

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[220] For instance Evanthia Kalpazidou Schmidt, Ebbe Krogh Graversen and Kamma Langberg (2003): Innovation and dynamics in public research environments in Denmark: A research-policy perspective, Evanthia Kalpazidou Schmidt, Ebbe Krogh Graversen and Kamma Langberg, Science and Public Policy (2003) 30 (2): 107-116.

doi: 10.3152/147154303781780605, Hoffman, (2009):"Changing Academic Mobility Patterns and International Migration, What Will Academic Mobility Mean in the 21st Century?", *Journal of Studies in International Education*, Volume 13 Number 3, Fall 2009 347-364.

[221] European Commission (2010): Brussels, 6.10.2010, COM(2010) 553 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Regional Policy contributing to smart growth in Europe 2020, SEC(2010) 1183.

[222] The upcoming programming period refers to 2014 - 2020.

[223] Examples include the 'Smart Specialisation Platform', bringing together expertise from universities, research centres, regional authorities, businesses and Commission services so as to help identify needs, strengths and opportunities. The data, policy analysis and information on research and innovation performance and specialisation from an EU-wide perspective (in particular the European Cluster Observatory, the Regional Innovation Scoreboard and Monitor and the Sectoral Innovation Watch). Platforms for mutual learning on the design and implementation of such strategies have been developed (including the CIP-funded "European Cluster Cooperation Forum" and the European Cluster Alliance and the FP7-funded 'Regions of Knowledge' and Research Potential projects). (European Commission 2010, 16.).

A further action that could be envisaged by the alignment of EU, national and regional strategies would target the removal of the imbalances observed between European Member States in terms of knowledge and research capacity by creating Centres of Excellence in the less developed Member States.

The idea was first proposed to the European Commission by the ITRE committee of the European Parliament that "*takes the view that announcing a competition for the foundation of cutting-edge research centres in disadvantaged regions is a suitable instrument for developing the European Research Area; considers that the award of aid in the form of a competition boosts dynamism and creativity, which can lead even in structurally weak regions to the successful creation of research and technology sites providing future-oriented jobs; considers that the candidates for the competition should be teams comprising one internationally recognised research institute and one disadvantaged region each, and that the scientific approaches underlying the proposals for foundations should be assessed on the principle of excellence; considers that, at the same time, the region should be required to come up with a viable overall approach constructing, for example with the help of structural funds and by creating an appropriate framework, an infrastructure amenable to research and innovation;*"[224]

The idea was taken up in the Commission's proposal on Horizon 2020 by the Directorate-General for Research and Innovation: "*Closing the research and innovation divide in Europe: There are significant regional disparities across Europe in research and innovation performance which need to be addressed. Measures will aim at unlocking excellence and innovation and will be distinct, complementary and synergistic with policies and actions of the Cohesion policy Funds. They include: – Linking in a competition emerging institutions, centres of excellence and innovative regions in less developed Member States to international leading counterparts elsewhere in Europe. This will involve teaming of excellent research institutions and less developed regions...*".[225]

Such a scheme would enable the EU to boost the innovation capacity and economic growth of convergence regions, by addressing the three main requirements for this to happen: know-how, financial support and an innovation-conducive environment. Teaming with a leading research partner from an advanced EU Member State would enable participants to define and put in place a research environment along international best practice lines that would attract top scientists to a European location. The structural funds could be used to create the research organisation/institution and ensure the operational costs for a certain period, allowing for top performers to be recruited. But a clear road-map would need to be developed to ensure that the level of financial support is adequate for the efficient deployment, allowing for research capacity to be built over a certain and well specified period of time, so that further funding is provided on the basis of the quality of the research produced.

[224] European Parliament resolution of 27 September 2011 on the Green Paper: From challenges to opportunities: towards a common strategic framework for EU research and innovation funding (2011/2107(INI)) – point 11: www.europarl.europa.eu/oeil/file.jsp?id=5918652 .

[225] European Commission (2011c) : Proposal for a Council Decision establishing the Specific Programme Implementing Horizon 2020 – The Framework Programme for Research and Innovation (2014-2020), COM(2011) 811 final, p. 78.

4.3. EU weaknesses in attracting top scientists: Significant barriers to implementation

The attractiveness of specific research environments and countries for researchers is naturally closely linked to issues such as the 'brain drain' or 'mobility". Brain drain issues have been widely debated in recent times, not least with the economic crisis and austerity measures in countries such as Greece and Portugal, where there are real concerns that young professionals will emigrate in large numbers.[226]

One should also bear in mind that the mobility of top researchers is often built upon the mobility of students: it becomes easier and thus one is more likely to relocate again if one has already done so in the past. Students and PhD students constitute the pool of tomorrow's potential top researchers and thus they should be viewed and treated as such. While the attractiveness of universities for students and young researchers is beyond the scope of the study reported here, it is clear that a certain path dependency exists between students' mobility and the mobility of top researchers. Mobility in the later stages of the researcher's career becomes easier and more likely with having been mobile in earlier stages. As indicated by some of the interviewees, doctoral students also tend to be good 'ambassadors' for the countries where they have studied. In this regard, it is noteworthy that the "winners" in the "brain drain competition" are very few: only five countries, Australia, the USA, France, Germany and the United Kingdom, attract 8 out of 10 foreign students in the OECD area. The United States has long been the most important receiving country, hosting over 30% of all foreign students, followed by the United Kingdom, Germany, France and Australia with 8%.[227] If students have positive experiences at an earlier stage of their research career, their experiences can be built upon and ultimately used in communicating and marketing the countries in question.

There are also 'soft issues' to be developed more systematically. The strongest European countries have a good brand in terms of the quality of life issues (e.g. the Finnish case where safety, security, childcare, basic education are usually referred to), while others provide particularly attractive working conditions and high wage levels cases (Germany in particular). Linguistic issues can provide bottlenecks in several countries as the language that is mainly used is often one of the national languages. A more comprehensive policy of using English across the research environments seems to be a requirement for success, as English is now the *lingua franca* of science.

One of the issues to be considered is the long-term nature of addressing top scientist attractiveness and both the virtuous and vicious circle that this entails. As attracting top scientists is a long, path-dependent process, those who have invested in R&D and in attracting top talent need to work considerably less than those trying to catch up.

The notion of vicious circle here refers to the fact that those that are lagging behind face increasing challenges in catching up due to the preconditions of economic austerity and the need to invest considerably in the development of high-level research environments.

When there are fewer resources available for the development of basic infrastructure, even less is typically available for attaining excellence and the competitive advantage required to gain visibility and succeed in global competition.

[226] See for instance Ackers, L. (2005), Adams, W. ed. (1968) and Bailey, T. (2003). Pierpaolo Giannoccolo (2005): "Brain Drain Competition" Policies in Europe: a Survey. University of Bologna - Department of Economics, Online article available at: http://amsacta.cib.unibo.it/1755/. The term 'diaspora' or 'intellectual diaspora' are equally used, e.g. Teferra, Damtew (2004): "Brain Circulation: Unparalleled Opportunities, Underlying Challenges, and Outmoded Presumptions", Paper prepared for the Symposium on International Labour and Academic Mobility: Emerging Trends and Implications for Public Policy. 21-22 October 2004. World Education Services. Toronto, Ontario, Canada.

[227] OECD, 2009.

5. CONCLUSIONS AND RECOMMENDATIONS

On the basis of available documents and data, our study shows that top scientists are attracted by stimulating research environments in research institutions that compete at a global level and which provide substantial funding for cutting-edge research. The evidence provided shows that geographically, the USA is still the dominant country attracting top researchers from all over the world, including Europe, because it provides the conditions for leading research to be conducted with a strong focus on quality. A strong focus on quality also characterises the research and innovation system of Switzerland which is a country that attracts a strong base of leading researchers. At the same time, there is evidence that other countries, such as China, India and Brazil are important alternatives for top scientists largely due to national strategies that are driven by a high-tech vision of successful scientific and technological competition at the global level.

The non EU countries considered in our study are very active in their headhunting activities. The most successful competitors provide a highly competitive wage level and this is an issue that needs to be addressed more actively. Some of the EU countries seek to address the competitive remuneration aspect in their policies, by giving more autonomy to universities and higher education institutions to set their own wage levels. If such measures are accompanied by a stronger focus on research quality and production they are likely to increase the chances of European universities and research organisations in their competition with leading universities in the USA and other countries.

In most European countries, there has been considerable brain drain over the years and the tendency was for their top scientists to move to the USA in particular. The current policy instruments deployed in such EU countries aim at attracting the returning researchers and those with already existing ties to the country in question, which form a large potential target group.

Among the main barriers in the EU countries, one can identify the lack of career paths for young researchers and the absence of a tenure track or permanency of academic positions. The wage level is also often seen as a competitive disadvantage. In some cases the research system and environment are difficult to access from the outside, with certification and language skills required as a starting point.

European Member States should probably be more selective. A higher proportion of resources in research and education should become available in order to attract future talents and to reward excellence. From a university's perspective, the quality of its academic and research staff is the main attractor of top researchers. This perceived notion of 'quality' undoubtedly drives reputations and has a significant influence on the research community, research funding institutions and policymakers and in this way enhances the ability to recruit the best staff and students. National policies should thus be more heavily targeted at developing and promoting the conditions in public institutions to identify and reward excellence in research. High quality research (and research environments) helps in the retention of talented young researchers. Often the countries which attract the best researchers early on in their professional careers will have a higher chance of retaining them throughout their career.[228]

[228] Ali, S., Garden, G., Culling, B, Hunter, R., Oswald, A., Owen, N., Ralsmark, H and Snodgrass, N. 2007. Elite Scientists and the Global Brain Drain A paper by the University of Warwick, U.K.

In addition to financial incentives and the quality factor, social and quality of life issues should not be overlooked. Perhaps the European countries should more actively promote such factors, e.g. the fact that there is healthcare and day care for the children, an education system that caters to international families etc. The Americans success has often been supported by the fact that the level of social capital in the most successful research environments is high and similar profiles should be promoted in European research environments.

The EU exhibits significant potential in terms of skills and has an infrastructure that provides the basis for developing centres of worldwide excellence in a variety of sectors and disciplines. There is also clearly an increasing tendency to draft strategies that seek to focus on specific disciplinary areas. Such specialisation seems to be a positive trend, as in many cases the successful and most attractive research environments can be built around such specialisation "clusters". This is the case both in the European countries and the competing countries. Europe and its Member States therefore should be more selective in their focus areas, especially when resources are likely to remain scarce.

A strong precondition for the success of such attempts is the need to join forces around common objectives across the EU and aligning the available funding instruments to this effect. There is also the issue of scale to be considered, as a European approach here is more likely to succeed as opposed to funding secured at the national and/or regional level. In preparing the upcoming programming period 2014-2020 increased attention, in both R&D&I and European Structural Funds-driven EU policies, is placed on innovation, smart growth and smart specialisation. The strategies foreseen for this purpose seek to ensure a more effective use of public funds, while at the same time stimulating private investment.

Our study shows that there is a need to develop such initiatives and direct them towards the creation of research environments that would attract top researchers. Important parameters to be taken into account should include: the focus on research, funding for long-term and high-risk research, less administrative burdens, flexibility in terms of hiring highly-qualified and promising researchers and attractive remuneration packages. Another idea that might have a very positive impact on the Convergence objective is the idea initiated by the European Parliament for a competition for funds linking stakeholders in less developed and advanced Member States with the objective of creating leading research centres in the former. If the attractiveness factors mentioned above are taken into account in the design of such centres there is a strong chance that the innovation capacity and economic growth of convergence regions can be boosted while such regions are also made better able to attract top scientists.

The European research Framework Programmes have been designed to promote European excellence in research. This is also one of the objectives of Horizon 2020. Our study has highlighted the very positive effects of Marie Curie Actions on the integration of researchers and of ERC for creating and confirming research excellence in Europe through leading research at the frontiers of knowledge. It is recommended that such actions are maintained and strengthened in terms of budgetary sources. This is particularly relevant for ERC: ERC grants may be a strong incentive to attract talent as they offer the opportunity to reward exceptional performance by overcoming rigidities inherent in the recruiting system of most European universities.

By increasing the number of projects to be funded under this scheme – as a result of increasing the budget earmarked for ERC, while keeping the strong requirements of scientific excellence – the better prospect of dealing with the large demand that was created for this scheme across the EU can be envisaged, but most importantly there is also a better chance of keeping both promising and leading researchers in Europe.

A further interesting aspect in relation to Horizon 2020 would deal with international cooperation. Setting up instruments and structures that support collaboration and exchanges may facilitate the ability of European scientists to benefit from greater interaction with top scientists from non-EU countries. Public RTD funding is growing at a fast pace in many third countries such as those ones outlined in this study. Consequently, increased opportunities undoubtedly exist to launch joint cooperation schemes. However, such schemes should be based on commonly defined strategies and objectives and be based on mutual commitments in order to produce concrete results. There are indications from the small number of interviews conducted with top researchers that leading American scientists would seem more inclined to participate in focused cooperation schemes, in areas where the EU has strong expertise and a solid research tradition, for example social care approaches and systems for the disabled and the elderly, *e*-inclusion and *e*-health. Also, they would feel more comfortable with the bottom-up approach of FET[229], which provides more freedom for creative research, this being an important aspect in their usual approach to research topics. Such issues would however need to be examined in a more systematic way so as to develop concrete cooperation strategies with well identified and mutually accepted goals and objectives.

One of the main difficulties faced by our study was the surprisingly paucity of evaluative information enabling a characterisation of what constitutes a 'top scientist' to be made. In view of their importance in developing scientific and research excellence, there remains a significant need to develop more systematic studies and monitoring tools for (a) qualifying and identifying top scientists and (b) studying their mobility patterns.

Such an analytical information framework would enable us to develop policies that would effectively address the attractiveness of the EU and of the various EU Member States with regard to leading global science performers and provide a sound basis to assess and fine-tune such policies for the benefit of European competitiveness in science.

[229] Future and Emerging Technology (FET) are funding schemes under the Research Framework Programmes of the Commission that support exploratory research to open up new themes across the full breadth of future information and communication technologies (ICT). "FET aim to go beyond the conventional boundaries of ICT and venture into uncharted areas, often inspired by and in close collaboration with other scientific disciplines" - http://www.pro-ideal.eu/FET

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ANNEX 1: LIST OF INTERVIEWS

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Alexander-von-Humboldt Professor
Gene Center and Department of Biochemistry
Ludwig-Maximilians-University Munich, Germany

Dr. Brigitte Angres
CEO of Cellendes GmbH (start up), Germany

Prof. Detlef Weigel
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Gerrit Rössler
DAAD (funding programs for German researchers working abroad or returning home)
New York, USA

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ETH Zürich, Switzerland

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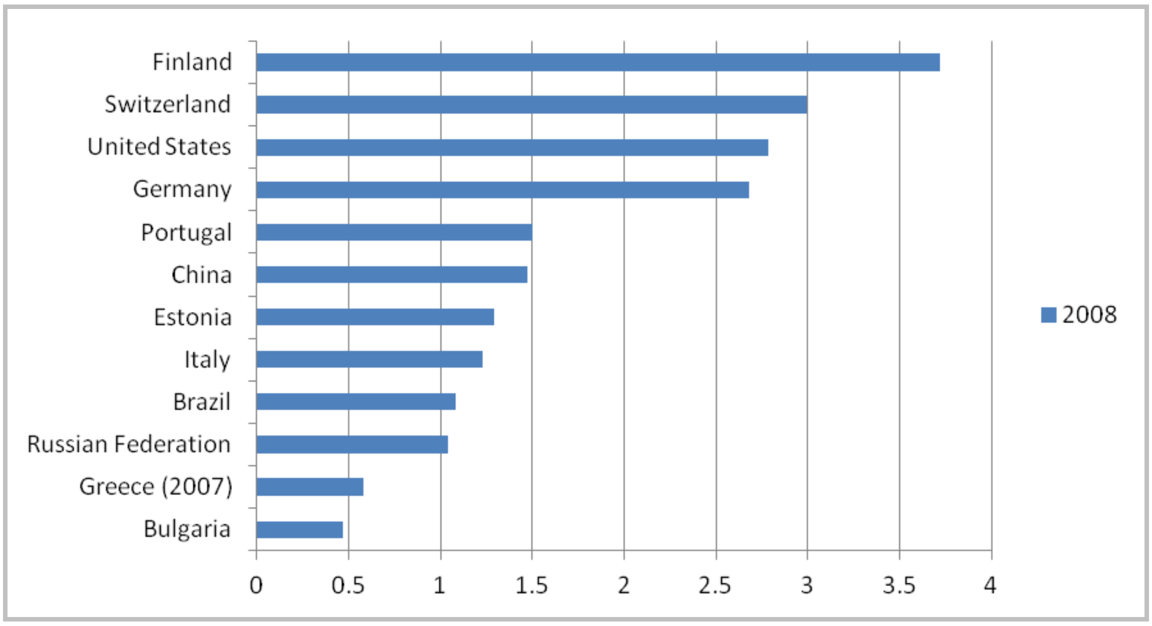
Associate Professor at Nanyang Technological University, Singapore
and
FiDiPro professor at VTT, Finland

Prof. Jeffrey Alan Hubbell
Professor (Ordinarius) of Institute of Bioengineering
Ecole Polytechnique Fédérale de Lausanne, Switzerland

Prof Elly Tanaka
Max Planck Institute of Molecular Cell Biology and Genetics and at Center for Regenerative Therapies, Dresden, Germany

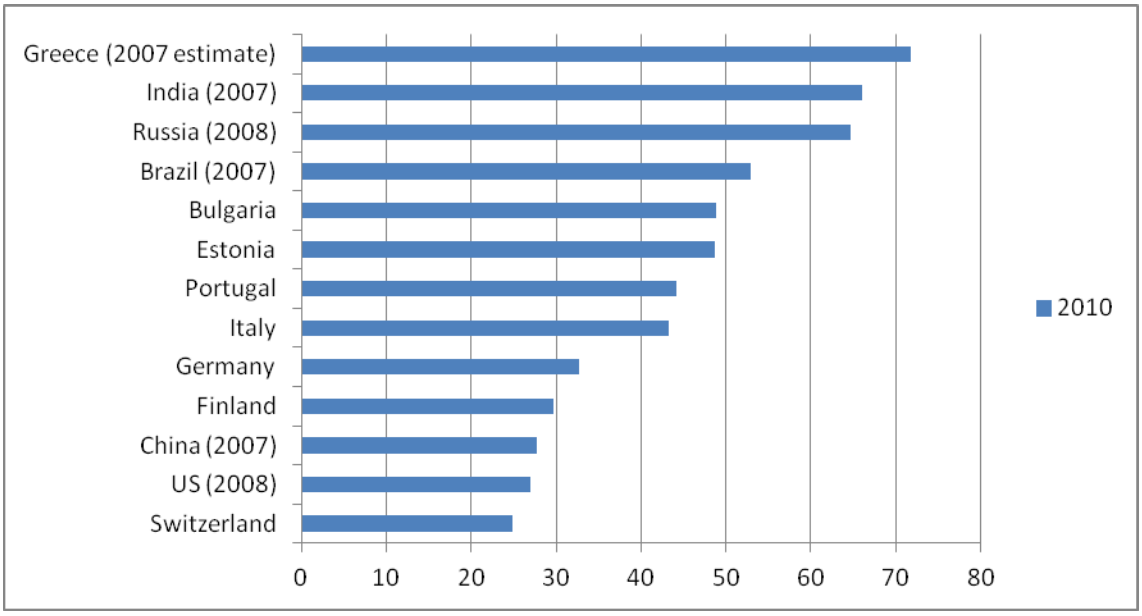
ANNEX 2: STATISTICS

Figure 3: Research and development expenditure GERD) (% of GDP) (2008)



Source: World Bank Statistics[230]

Figure 4: Share of public sector R&D: % of GERD (2010)

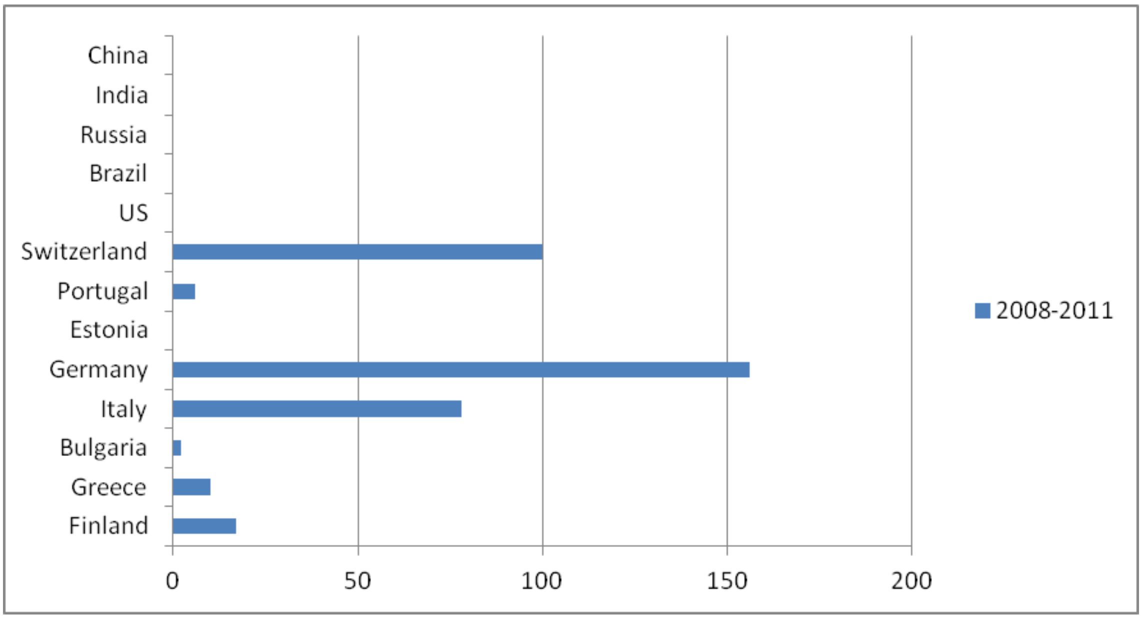


Source: ERAWATCH Country Profiles[231]

[230] The most recent statistical data available for most countries is from 2008 since data collection lags behind a few years. See: http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS.

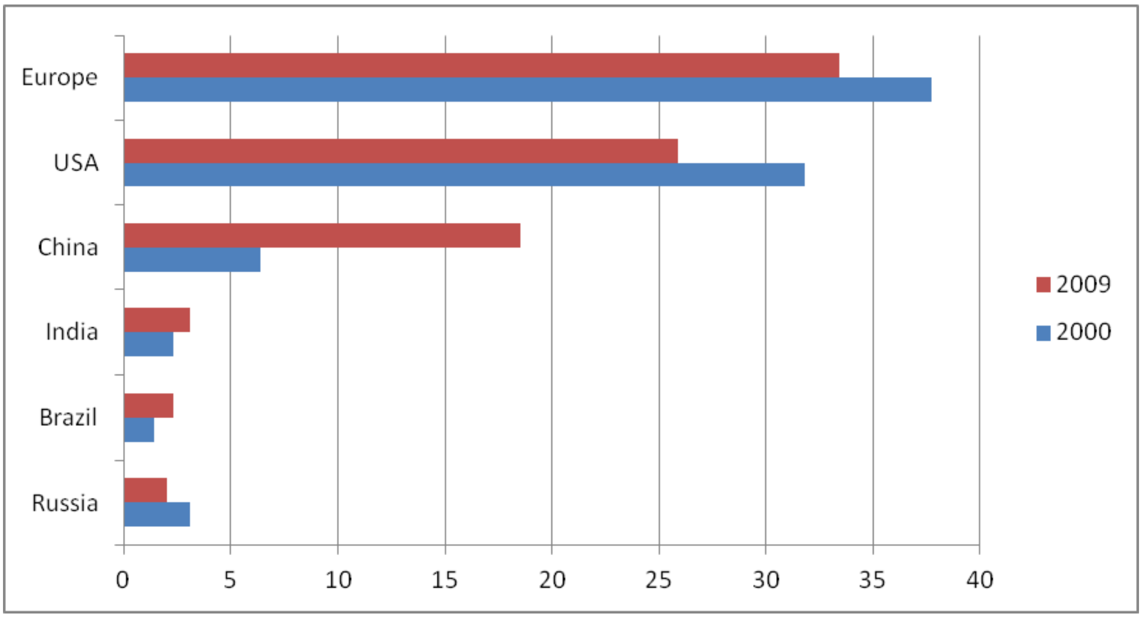
[231] See: http://erawatch.jrc.ec.europa.eu/erawatch.

Figure 5: ERC grants 2008-2011 (country of host institution)



Source: European Research Council Statistics, 2012[232]

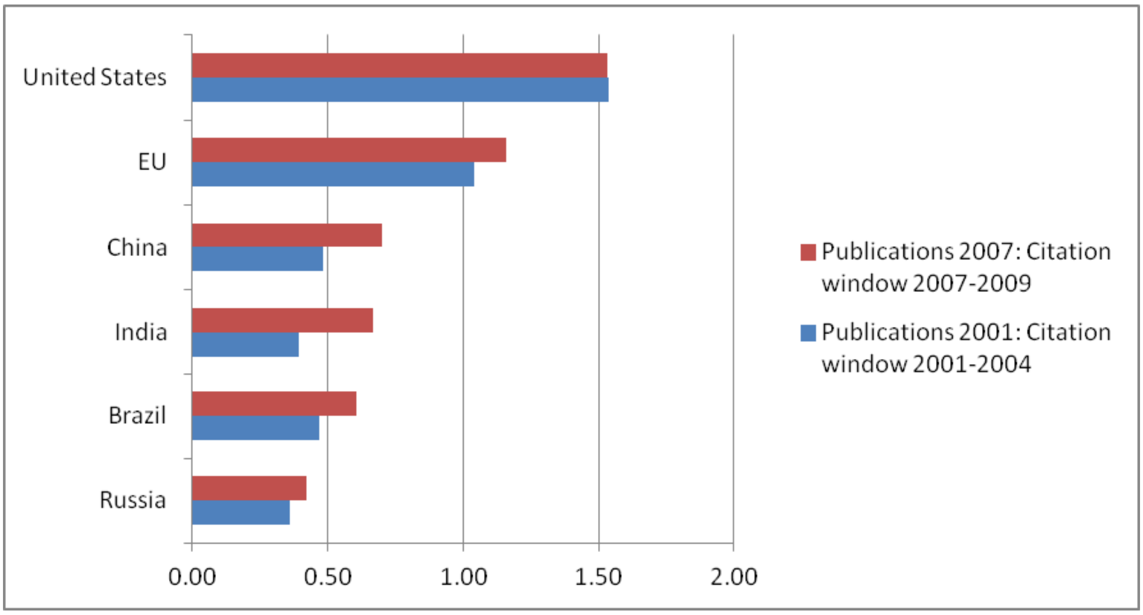
Figure 6: World shares of scientific publications (%) 2000 and 2009



Source: DG Research and Innovation; Data: Science Metrix / Scopus (Elsevier); Notes: Full counting method, Data for 2009 are provisional

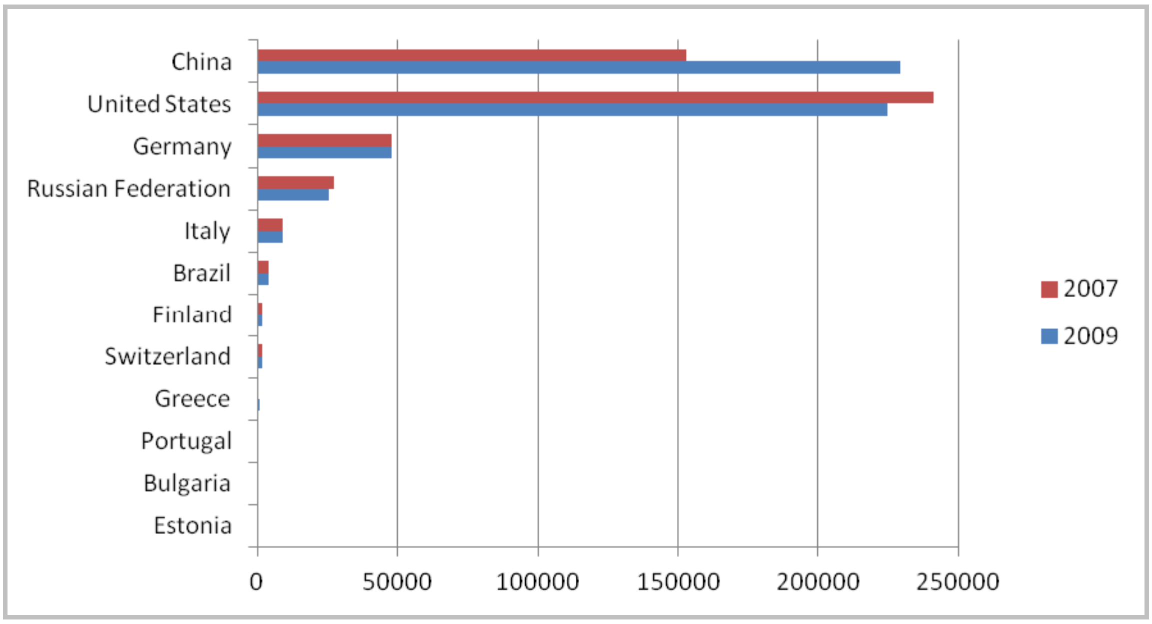
[232] See: http://erc.europa.eu/sites/default/files/document/file/erc_2011_adg_statistics.pdf.

Figure 7: Contribution to the 10% most cited scientific publications (2001 and 2007)



Source: DG Research and Innovation; Compiled by Science-Metrix using data from Scopus (Elsevier)

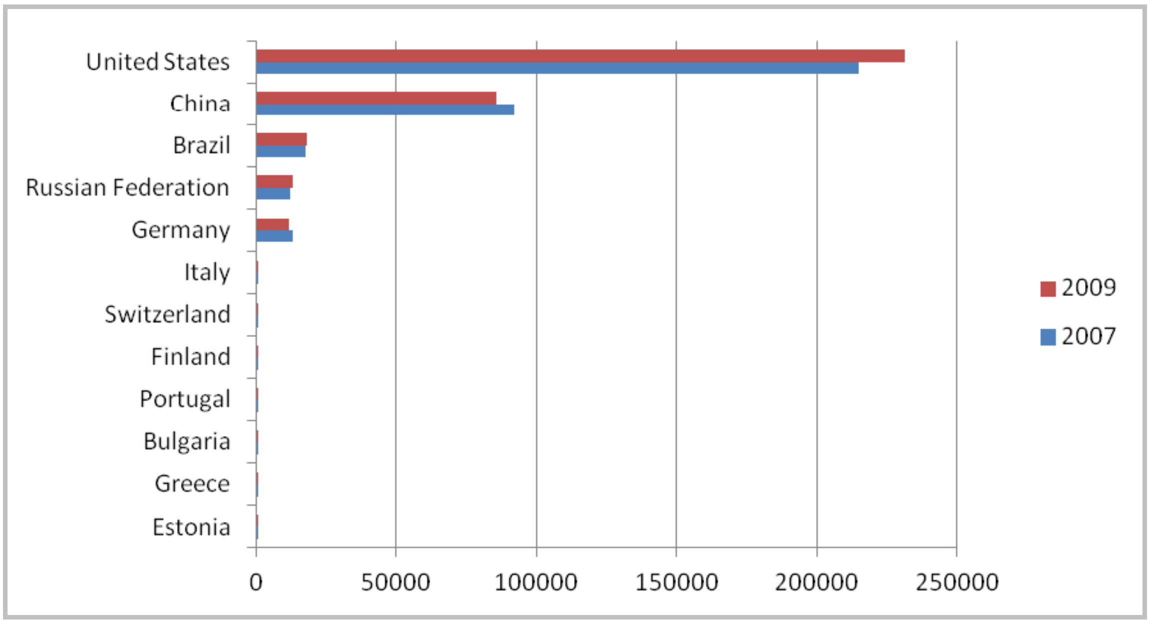
Figure 8: Patent applications, residents (2007 and 2009)



Source: World Bank Statistics[233]

[233] See: http://data.worldbank.org/indicator/IP.PAT.RESD.

Figure 9: Patent applications, non-residents (2007 and 2009)



Source: World Bank Statistics ((http://data.worldbank.org/indicator/IP.PAT.NRES)

NOTES

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PHOTO CREDIT: iStock International Inc.

ISBN 978-92-823-3781-3
doi: 10.2861/94872

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