Support for continued data collection and analysis concerning mobility patterns and career paths of researchers

Deliverable 7 – Researcher Indicators Report

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LIST OF ACRONYMUS

CDH	Career of Doctorate Holders
EC	European Commission
EEA	European Economic Area
ERA	European Research Area
EU	European Union
EU15	European Union with 15 Member States (the first 15 adhering countries)
EU27	European Union with 27 Member States
EUA	European University Association
EURODOC	The European Council of Doctoral Candidates and Junior Researchers
FOS	Field of Science
FTE	Full Time Equivalent
GCI	Glass Ceiling Index
HC	Head Count
HEI	Higher Education Institution
HRST	Human Resources in Science and Technology
HRSTC	Human Resources in Science and Technology-Core
HRSTO	Human Resources in Science and Technology - Occupation
HRSTE	Human Resources in Science and Technology – Education
ICT	Information and Communication Technology
IIE	Institute for International Education

IISER	The Integrated Information System on European Researchers
IPTS	Institute for Prospective Technological Studies
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISER	Institute for Social & Economic Research, University of Essex
IUS	Innovation Union Scoreboard
JRC	Joint Research Centre
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne, or Nomenclature of economic Activities in the European Union
NASA	National Aeronautics and Space Administration
NCSES	National Center for Science and Engineering Statistics
NEH	National Endowment for the Humanities
NIH	National Institutes of Health
NSF	National Science Foundation
OECD	Organization for Economic Cooperation and Development
R&D Personnel	Personnel employed in Research and Development Activity
S&E	Scientists and Engineers
SOE	Sector of Employment
USED	United States Education Department
USDA	United States Department of Agriculture

EXECUTIVE SUMMARY

In this study we selected and updated a selection of indicators on the state and development of the European research system (EU and Member State level), particularly the stock, mobility and overall career path of researchers.

Attention has been paid to stocks and flows of researchers at different stages of their career (R1-R4), employed in different fields of science and across the four sectors of activity (Government, Higher Education Institutions, Business Enterprises and Not-for-Profit Organizations).

This study puts particular emphasis on indicators related to various dimensions of mobility:

- Geographical mobility
- Intra-EU27 mobility and in or out of EU27
- Sectorial Mobility
- Virtual Mobility

Where data was available, the trends over the period 2000-2010 have been analysed and a comparison on the basis of the chosen indicators has been provided. We compared EU27 with other non-EU27 European countries and EU27 with its main non-EU competitors, particularly the US and Japan.

In what follows we summarize the main findings for each indicator or group of indicators.

Key findings on Indicator 1: Stock of researchers in EU27

- In 2010, the stock of EU27 researchers as full-time equivalents equalled 1.589 million, representing 0.7% of the active working population. The stock increased by about 10% compared to 2007; but in the same period the share of researchers in the active population did not change. In headcounts (HC), the stock of researchers amounted 2.320 million, which is 7.5% higher than in 2007.
- Heterogeneity within the EU27 is large, both measured in full-time equivalents and in headcounts. In 2011, the share of full-time equivalent researchers in the active population ranged from 0.2% (Cyprus) to 1.5% (Finland). The growth rates of the shares also show large differences between 2000 and 2010.
- The number of full-time equivalent researchers in the EU27 is slightly higher than in the US and China, and much higher than in Japan. In EU27, between 2000 and 2010, the annual average growth rate was around 4%. In the US and Japan this annual growth rate has been lower. China, on the contrary, experienced much faster growth, especially from 2004 onwards and is 'catching up', from this perspective.
- The share of female researchers (HC) in EU27 was 31.1% in 2005 and has steadily risen to 32.9% in 2010. This share is above 45% in Lithuania, Latvia, Bulgaria and Portugal. In several other countries this share is below 30%, such as Austria, The Netherlands, France and Germany.

Key findings on Indicator 2 and Indicator 3: Evolution of the number of researchers by Sector of Activity and Field of Science and Gender over time

- In 2010, about 40% of EU27 researchers (FTE) were employed in the Higher Education Sector and slightly more (around 45%) in the Business Enterprise Sector. The Government Sector employs about 10% of the researchers. As a result, more than 55% of researchers are employed in the public sector.
- The Eastern EU27 countries show the highest percentage of researchers active in the public sector (Government and Higher Education Institutions), with Bulgaria at the top (52.4%). Employment in the Business sector in Slovakia, Bulgaria, Lithuania, Latvia and Poland is less than 20%. On the contrary, Germany, Denmark, Ireland, France, Austria, Finland, Sweden, along with Malta and Luxembourg, all have more than 50% of their researchers employed in the Business Enterprise Sector.
- In the US, China, Japan and South Korea, the share of researchers in the Business sector is much higher than in EU27; with around 78% in the US, 65.9% in China, and 76.5% in South Korea.

Key Findings on Indicator 4: Tertiary degrees with academic orientation awarded in EU27, Japan and US in the period 2000-2010

- In the EU27, more than 3.6 million tertiary degrees with an academic orientation (ISCED 5A) were awarded in 2010.[1] This is a much higher number than in Japan (640,000) and the US (around 2.5 million).
- Between 2000 and 2010, the total number of such degrees went up by almost 1.5 million in the EU27. In the US and Japan, this rise in the number of degrees was less prominent, respectively 800,000 and 26,000.
- Over the period 2000-2010, the first stage tertiary degrees with an academic orientation (ISCED 5A) increased at an average annual rate of 5.1% in the EU27, a much higher rate than in US (3.2%) and Japan (0.7%).
- Poland, UK, France, Italy and Germany have been awarded the highest numbers of tertiary degrees with an academic orientation. Taken together, these countries, with Romania and Spain, have awarded 75% of the total number of degrees with an academic orientation in the EU27.
- The Social Sciences (more specifically Business and Law) is the field with the highest number of tertiary graduates (ISCED 5A & 6), 35.7%. Health and Welfare follows with 15%. The lowest figures are in Agriculture and Veterinary (1.6%) and Services (4.2%). There is, however, strong heterogeneity across Member States.
- All fields of education have experienced an increase in tertiary degrees with an academic orientation. The highest increase has taken place in the field of Services (10%), Health and Welfare (7.9%) and Social Sciences, Business and Law (5.9%). Science, Mathematics and Computing, and Engineering, Manufacturing and Construction had a growth rate below the average (4.2% and 4.7%, respectively).
- From 2000 to 2010 the number of Science and Engineering (S&E) degrees awarded in the EU27 increased by 55%, but the share of such degrees in the

[1] It should be noted that the Italian data are missing for the years 2009 and 2010. They have been estimated by linearly interpolating the 2008 and 2011 data.

total number of degrees with an academic orientation has not changed significantly (1% point increase with respect to 2000). There was a reduction (2%) in the share of S&E degrees both in the US and Japan over the same time period.

- In 2010 the highest shares of S&E degrees were awarded in Finland (32%). Germany, Greece France and Austria follow (all between 26% and 29%).
- The share of female graduates (ISCED 5A) is higher than 50% in all the EU27 Member States and has increased almost everywhere in the period 2000-2010. The Baltic States and the Eastern European Member States have the highest share with a maximum value of 72% to be found in Latvia.

Key findings on Indicator 5: Doctoral degrees: international comparison

- In 2010 about 115,000 doctoral degrees[2] were awarded in the EU27 compared with 64,000 in the US and 16,000 in Japan. The average annual growth rate for EU27 in 2000-2010 was 3.2%, which is less than for the US (4.5%) but more than for Japan (2.7%).
- The Member States with the highest number of doctoral graduates aged 25-34 per 1,000 persons of the same age population are Germany (2.1%), Slovakia (2%) and Austria (1.6%). Switzerland shows a higher value (2.7%). The average at the EU27 level was about 1.6% in 2010, up from 1.1% in 2000.
- The share of EU27 female doctorate graduates in 2010 was 46%. Latvia, Lithuania, Portugal, Italy, Estonia, Finland and Poland display figures above 50%. In the US the share is higher (53.4%), while it is lower in Japan (28.4%). In general, there is an increasing trend.
- In the EU27 the share of doctoral degrees in Science and Engineering from the total number of doctoral degrees awarded in 2000-2007 is about 42%; in the US and in Japan, the corresponding figures are 34% and 33% respectively.
- Both in EU27 and in the US, the share of degrees in science, mathematics and computing was higher than in engineering, manufacturing and construction.

Key findings on Indicator 6: Intra-EU inflows of doctoral candidates

- The total number of EU27 doctoral candidates in 2010 was about 735,000. The EU27 share of doctoral candidates studying in an EU country which is not their country of citizenship is 8%.
- 7,600 German, 5,600 Italian, 3,000 Greek, 2,500 Portuguese and 2,300 Polish doctoral candidates were studying in a Member State other than their country of citizenship (in 2010).
- Slovakia, Bulgaria, Ireland and Portugal are the countries with the highest share of doctoral candidates studying in another Member State as a percentage of national doctoral candidates in their home country (higher than 15%, not taking into account the small countries Cyprus, Malta and Luxembourg). Italy and Greece follow at around 14%.
- Austria and UK have relatively low shares (below 2%) of doctoral candidates in other Member States, as a percentage of doctoral candidates with national citizenship.

[2] It should be noted that the Italian data are missing for the years 2009 and 2010. They have been estimated by linearly interpolating the 2008 and 2011 data.

Key findings on Indicator 7: Intra-EU outflows of doctoral candidates

- In 2010, the Member State with the highest number of doctoral candidates who are citizens of another Member State was the UK; the figure was above 14,000 and amounts to 34% of the total number of EU doctoral candidates studying in a Member State other than their country of citizenship. After the UK comes France (5,734), Austria (4,880) and Spain (3,997).
- Apart from Luxembourg, the UK and Austria are also the Member States with the highest number of doctoral candidates with citizenship from another Member State as a share of total doctorate students in the country; in 2010, the figure was respectively 16.4% and 18.2%. There was a general positive trend after 2005. The UK and Austria are followed by Ireland (16%), Belgium (13.6%) and Denmark (12.4%). Among the EU27 large countries (in terms of population), Poland hosts the smallest share of foreign doctorate students of the total amount of doctorate students.
- The UK also has the largest net inflow of doctoral candidates from other Member States (over 13,000). Austria, France and Spain follow but at quite a distance; Italy, Portugal and Poland show the highest net outflows.

Key findings on Indicator 8: Inflows of doctoral candidates into EU27

- In 2010, about 20% EU27 doctoral candidates came from non-EU countries.
- Among extra-EU doctoral candidates, almost 7,500 (around 7% of the total inflow) come from China and 3,400 from Brazil. The share of students coming from China and India substantially increased in the period 2005-2010.
- Almost 2/3 of the doctoral candidates coming from non-EU countries go to France or the UK.

Key findings on Indicator 9: Mobility of EU27 graduate students out of Europe

- The number of EU27 born students enrolled in graduate and professional programmes in the US went up from about 55,600 in 2003-2004 to about 58,100 in 2011-2012. There was, however, no steady increasing trend.
- Between 2000 and 2011, the number of EU born citizens who were awarded a doctoral degree in the US increased from 1,882 to 2,021. However, this increase has not been steady over the years. In 2011, Germany was the country with the highest number of doctorates awarded (445), followed by Italy (193), Romania (183) and France (180).
- The number of EU citizens who earned a doctoral degree in the US in 2011 as a share of all EU citizens who earned a doctoral degree in that same year was about 2%. In 2000 this share was higher (2.5%).
- The number of US visas given to EU27 doctoral candidates increased from 1996 to 2007, but in the following two years there has been a sharp decline. It is not clear whether this is a cyclical or a structural phenomenon.
- There is some data on EU born doctoral candidates for Japan. The total number of doctoral candidates in Japan was around 500 in 2010.

Key findings on Indicator 10: EU27 researchers abroad

- No complete and/or comparable data on the number of EU researchers (by occupation and education) working outside the EU27 is available.
- We started from the data on EU born individuals who have earned a doctoral degree in the US and who stated that they had also worked as researchers there. We then estimated, making the necessary assumptions, the stock of EU born researchers working in the US between 2000 and 2011. The more likely value for this stock is around 15,000 in 2011 up from about 9,000 in 2000.
- On the basis of further assumptions, we also estimated the stock of EU born researchers in Australia, New Zealand, Canada and Mexico. According to those estimates, 34,000 EU born researchers were working in these 4 countries plus the US in 2011. The trend is assumed to be positive. However, these results are to be interpreted with caution.

Key findings on Indicators 11-18

- These indicators have been discussed in depth in the MORE2 EU Higher Education Institutions Survey and the key findings are presented in Section 6 of this report.

Key findings on Indicators 19, 20 and 21: Virtual mobility

- 11% of all scientific publications in the whole EU27 are situated in the top 10% most-cited publications worldwide. Netherlands, Denmark, Belgium, UK, Sweden, Finland, Austria and Germany are the best performing countries.
- In terms of co-publications, the EU27 average was around 300 publications per million of the population in 2011.

Key findings on Indicators 22 and 23: Working conditions - contract and position

- These indicators have been discussed thoroughly in the MORE2 EU Higher Education Institutions Survey and the key findings are presented in Section 6 of this report.

Key findings on Indicators 24 and 25: Working conditions - gender

- On average, throughout the EU27, the GCI (Glass Ceiling Index) equals 1.8 in 2010, which means that slow progress has been made since 2004 when the index value was 1.9. In 2010, none of the countries had a GCI value which was equal to or less than 1. Its value ranges from 3.6 in Cyprus to 1.3 in Romania (and Turkey). Aside from Cyprus, the highest GCI was reported in Lithuania and Luxembourg. Between 2004 and 2010, the GCI has decreased in most countries.
- The share of female students enrolled in 2010 in the first two levels of University education (students and graduates of largely theoretically-based programmes providing sufficient qualifications for gaining entry to advanced research programs and professions with high skills requirements), were 55 % and 59% respectively.

- Men outnumber women at the third level and are also more numerous among the enrolled students at PhD level. Indeed, about 46% of PhD graduates are women.
- A comparison between 2002 and 2010 shows an improvement in women's relative position at the doctoral level and at the different stages of the academic career, as captured by grades A, B and C. This positive progress is nevertheless slow and should not mask the fact that, in the absence of proactive policies, it will take decades to close the gender gap and bring about a higher degree of gender equality.
- Although a picture of strong vertical segregation transpires through the analysis of the overall situation in the academic world, the situation varies considerably according to the field of science considered. Despite girls' impressive gains in education, progress has been uneven; Science and Engineering remains an overwhelmingly male field.

Part 1 FRAMEWORK FOR THE RESEARCHER INDICATORS

1 INTRODUCTION

In order to reach the important goal set in 2008 of creating a European Research Area, the European Commission has taken a series of actions to ensure that researchers across the EU benefit from structured training, attractive careers and from the removal of barriers to their mobility.

To make these actions effective it is necessary to have updated information on researchers' current situation in European countries. The particular aspects of researchers' work most relevant to the creation of policy actions are those related to their numbers, career paths, working conditions, mobility and job satisfaction.

To this end, the Commission launched a project to collect and organize a set of internationally comparable data, indicators and analysis to support policy choices at both European and national level. The Mobility of Researchers in Europe (MORE) study was launched by the Commission in 2008 and the results were published in 2010[3]. The MORE survey was based on four surveys (of researchers working in Higher Education Institutions, of those working in industry, in public non-University institutions and finally on EU researchers who worked in US and US researchers who worked in EU). The MORE1 study updated the IISER[4] 2007 indicators, provided for the first time comparable data between EU Member States on researchers' mobility and added a wealth of new information on factors which inhibit or support such mobility as well as additional information on inter-sectorial mobility.

The present study, "Support for Continued data collection and analysis concerning mobility patterns and career paths of researchers"[5], has the objective of updating, improving and further developing the current set of MORE1 indicators in order to assess the impact on researchers of policy measures adopted thus far and to highlight new needs and priorities. The fifth work package (WP5) of the MORE2 project aims to update and revise IISER indicators currently available - by filling the gaps where possible (both geographically and chronologically) and increasing the degree of standardization - and to develop new indicators.

Accordingly, WP5 is divided into three main tasks:

a) Update MORE1 indicators and propose new indicators.
b) Identify missing information and critical issues.
c) Analyse and release metadata.

[3] Idea Consult et al, 2010.

[4] IISER 2007 *Integrated Information System on European Researchers II*, Sixth Framework Programme Priority: Structuring the European Research Area, Human Resources and Mobility, November 2007. The project aimed at (i) collecting existing information at national level in order to provide a first dynamic, albeit partial, overview of the European scene in this area, and (ii) conducting an analysis of gaps and methodologies in order to derive a full-fledged information system. The project was undertaken under the coordination of the Institute for Prospective Technological Studies (European Commission, Joint Research Centre).

[5] IDEA Consult et al, 2013a. MORE2 - Support for continued data collection and analysis concerning mobility patterns and career paths of researchers. European Commission, DG Research and Innovation.

Regarding the first task, the selected IISER indicators are updated and long term time series are provided where data are available. Moreover, new indicators are introduced, taken either from other WPs of the present project or from recent (or still on-going) studies. Among others, the new indicators refer to EU27 HRST employed in countries outside Europe, to researchers' virtual mobility and to the influence of gender on the career paths of researchers.

As to the second task, a careful analysis of data availability for the 2000-2010 period has been carried out. In particular, we refer to the data sources listed in Table 1.

Table 1: Main data sources used in WP5

ORGANIZATION	DATASET
EUROSTAT	✓ Total R&D personnel and researchers by sectors of performance, as % of total labour force and total employment, and by sex [rd_p_perslf]; ✓ Total R&D personnel and researchers by sectors of performance, sex and fields of science [rd_p_perssci]; ✓ Researchers (HC) in government and higher education sector by age and sex [rd_p_persage]; ✓ Total R&D personnel and researchers by sectors of performance, qualification and sex [rd_p_persqual]; ✓ Graduations in ISCED 3 to 6 by field of education and sex [educ_grad5] ✓ Tertiary education graduates [educ_itertc]; ✓ Foreign students in tertiary education (ISCED 5-6) by country of citizenship [educ_enrl8];
OECD	✓ Main Science and Technology Indicators ✓ International Migration Statistics
Institute of International Education	✓ Open Doors 2012 Data ✓ Open Doors Report on International Educational Exchange ✓ International Students Data ✓ International Scholar Data
National Science Foundation (NSF)	✓ Science & Engineering Indicators
NSF/NCSES/NIH/USED/USDA/NEH/NASA	✓ Survey of Earned Doctorates (SED)
Australian Government	✓ Selected Higher Education Statistics
Japanese Ministry of Education Culture, Sports, Science and Technology	✓ Lifelong Learning Policy Bureau

Finally, concerning the third task, we provide a list of all indicators and sub-indicators specifying their geographical coverage and their source.

In detail, this report is organized as follows. We introduce the framework for the researcher indicators by providing clear definitions of the phenomena to be analysed and illustrating the process that has led to the selection of the chosen indicators. We go on to present all the indicators, discussing the main results concerning EU countries and how they compare with a number of relevant non-EU countries. Finally, we summarize the key-findings and suggest some policy measures.

Annex 2 to the Report includes a brief presentation of other on-going or recently completed studies on Researchers' mobility, a list of the shortcomings of Researchers' Mobility Indicators and the metadata for each indicator.

2 DEFINITIONS

To study the 'mobility' of 'researchers' it is important to clarify how these two terms are defined and interpreted. We present the definition and interpretation below.

2.1 Definition of researcher

The definitions of a 'researcher' currently in use originate either from the Canberra Manual[6], which covers Human Resources in Science and Technology (HRST); from the Frascati Manual[7] that covers research and experimental development and R&D personnel; or from the Institute for Social & Economic Research (ISER) expert group[8] which proposed a definition for researchers in science and engineering and for technicians.

The **Frascati Manual (FM)** was published in the early 60's and has been the first of the OECD manuals on the measurement of resources devoted to Sciences and Technology activities. It 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" (OECD, 2002, p. 93)

According to the **Canberra Manual**: "Human Resources in Sciences and Technology (HRST) are persons who either have higher third level education or persons who are employed in positions that normally require such education" (OECD, 1995, p. 16). A sub-group is Human Resources in Science & Technology – Core (HRSTC) defined as those "who are both qualified tertiary educated graduates from a Science and Technology field of study and working in a Science and Technology occupation as professionals or technicians".

Finally, the **ISER expert group** defines the "SET professionals" as people who fulfil both the following criteria:

1) Attaining a tertiary education at or above ISCED97 level 5;
2) Having an occupation in specific areas such as those identified by the ISCO codes 211-214, 221-222 and 223.

All these definitions have their own strengths and weakness, being either too general or too restrictive. For example, both the Canberra and the ISER definitions do not seem to include doctoral candidates among researchers, the reason being that in many countries they are considered students rather than employees.

In this report all the data referred to researchers are based on the FM definition of researchers. This is the same definition adopted by the MORE1 study and by other work packages of the MORE2 study. It is also necessary to provide a clear definition of the different 'stages' of researchers' careers.[9]

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6 See OECD, 1995.

7 See OECD, 2002.

8 See Rose D. et al., 2001. See also Inzelt, 2012, p.8.

9 The ERA Steering Group on Human Resources and Mobility in May 2011 has adopted the definition of the European Framework for Research Careers, that describes four broad profiles:

2.2 Definition of mobility

Researchers' mobility is essential for achieving the Fifth Freedom: the free flow of knowledge. Consequently, it is one of the most important objectives of the European Research Area (ERA). However, as emphasized in the ERA Framework Public Consultation - Comprehensive Report[10], mobility also serves "the objective of improving research while providing more attractive research careers".

The term 'mobility' is often linked to the geographical concept of movement. Indeed, mobility has several meanings, among which the following are of particular interest in order to define and interpret the indicators on researchers.

Geographical mobility refers to the physical mobility of researchers from one geographical area to another and includes both inflows and outflows. It can be either national or international; within the European Union or between a European Union country[11] and a third country.

Sectorial mobility refers to the mobility of researchers within the same sector (intra-sectorial mobility), e.g. moving from one University to another; or between different sectors (inter-sectorial), e.g. moving from a research position in the public sector to one in the private sector.

Mobility can also refer to a change in the field of research or inter- and trans-disciplinary mobility which might take place during the career as a result of the curiosity of the researcher or from the need to deepen her research.

With respect to duration, mobility can have the following definitions (already surveyed in detail in WP1 and WP2):

- Employer mobility refers to mobility implying a change of employer.
- More than 3 month mobility refers to researchers that move for a period longer than three months.
- Less than 3 month mobility refers to researchers that move for a period shorter than three months.

A relatively new concept is that of virtual mobility. It refers to situations in which the exchange of knowledge or collaboration between researchers takes place through the use of the World Wide Web (www.) or, more generally, of ICT devices made available by technological advancements in the last thirty years. This type of mobility can function as a substitute for geographical mobility, particularly the "less than 3 months mobility" defined above.

Mobility can also assume different meanings, depending on the actors involved:

- PhD mobility refers to mobility in the phase of working towards obtaining the doctoral degree;
- Post-PhD mobility refers to mobility of researchers after their doctoral stage (at stage R2 to R4[12] of their careers).

- R1 - First stage Researcher (up to the point of PhD).
- R2 - Recognized Researcher (PhD holders or equivalent who are not yet fully independent).
- R3 - Established Researcher (researchers who have developed a level of independence).
- R4 - Leading Researcher (researchers leading their research area or field).

These definitions apply to all researchers in the FM meaning, independently of the sector of activity or the Field of Science (FOS). The relevance of the latter definitions to this study is linked to the Indicators on International and on Intersectoral mobility at different stages in the career that are presented below. Those indicators are worked out in the MORE2 EU HEI survey and discussed at length in the relevant report. Therefore, for a more detailed description of attitude and expectations in each of the career stages, we refer to IDEA Consult *et al.,* 2013b.

10 European Commission, 2012b.

11 Here we refer to the whole EU27, plus the EEA and the Candidate countries.

12 See IDEA Consult *et al*., 2013b.

2.3 Definition of internationally mobile students and foreign students

In 2006, UNESCO, EUROSTAT and OECD started a process to homogenize the relevant definitions in order to enable comparisons to be made between data collected in various countries. Among others, of special interest to this study is the definition of the "mobile student"[13].

A 'mobile student' is defined as a foreign student who has moved from his/her country of origin[14] to another country (also called country of destination) with the only (or principal) objective of studying. More precisely, the status of the mobile student is dependent on crossing a border for the purpose of education; it is not dependent on being a formal resident in the reporting country of destination.

The status of mobile student is maintained as long as continued education at the same level of education is sustained. This may involve several consecutive educational programs with no or only minor gaps (less than one year) between them. Note that all tertiary programs are considered as belonging to the same level. A mobile student entering an ISCED[15] 5A program at the tertiary level is still considered to be a mobile student if upon graduation he/she continues in an ISCED 6 program in the same destination country.

A different, but related, concept is that of the 'foreign student', defined as a non-citizen of the country in which she/he studies[16],[17].

Finally, in a given year a student will be considered a 'citizen from EU-countries' if in that year the country he/she is citizen of an EU Member State. Thus, from January 2007, all students having citizenship from one of the 27 Member States are defined as EU citizens.

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13 In this report, the terms 'Mobile students', 'International students' and 'International mobile students' are synonymous.

14 'Country of origin' is defined as the country of permanent or usual residence, or the country of prior education, where her/he received the previous highest degree.

15 ISCED stays for *International Standard Classification of Education*. UNESCO has adopted it in order to allow comparisons between educational systems and levels of education in different countries. In this study, we refer to levels ISCED 5 and ISCED 6 only. The former is composed of ISCED 5A (tertiary programmes that are largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programmes and profession with high skills requirements) and ISCED 5B (tertiary programmes practically oriented or occupationally specific mainly designed to transfer the practical skills and the know-how needed for employment in a particular occupation). ISCED 6 refers to tertiary programmes, which lead to an advanced research qualification, e.g. Doctorate or PhD programmes.

16 See Eurostat, Metadata on Education. See also Inzelt, 2012, p. 9.

17 As we will discuss further in the report, one of the main problems for collecting comparable data lies in the different definitions of citizenship countries adopt based upon their immigration policy.

3 SELECTION OF INDICATORS

3.1 Introduction

In order to meet the targets set in the Europe 2020 growth strategy[18] and in the Innovation Union flagship[19], Member Countries have to make the research profession more attractive: they should reduce mobility barriers and should also appeal to top scientists from other geographical areas. All these actions demand more effort and resources.

The United States, with 60% of the European population (300 million inhabitants in US; 500 million inhabitants for EU27) have more or less the same number of researchers as the EU: 1.4 million in the US compared to 1.5 million in the EU. Moreover, the researcher population in Europe is ageing and many will retire in the near future[20].

The situation is obviously very different across the 27 Member States, but together they need to create at least 1 million new researcher positions in order to meet one of the Europe 2020 Priorities, namely: "smart growth, through more effective investments in education, research and innovation". This means making the research career more appealing to younger generations[21] and removing obstacles to mobility and cross-border cooperation within the EU27 and with third countries. However, this also means implementing all possible measures in order to increase the attractiveness of Europe as an area where high quality research can be carried out.

In this section we shall present selected indicators (some of them are updates of MORE1 indicators, others are newly introduced) in order: i) to understand the past development and the current situation of the research profession in the EU27; ii) to monitor the progress of each country towards the aforementioned goals. Where possible, the same indicators will be applied to other countries, especially to the main 'competitors' of the EU in attracting highly-skilled researchers.

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18 The second of the five targets is that 3% of the EU's GDP -public and private combined- has to be invested in R&D/innovation. See European Commission (2010b).

19 'Flagship initiatives' provide a framework through which the EU and national authorities mutually reinforce their efforts to reach the EUROPE 2020 Priorities. The Innovation Union Flagship is a plan that contains over thirty actions points/commitments, aiming to achieve the Priority of a SMART GROWTH. Among those thirty-four commitments, the *first* one is to have in place strategies to train enough researchers to meet national R&D targets and to promote attractive employment conditions in public research institutions, also keeping the attention high on gender considerations. The *fourth* one devotes its attention to the realization of a European Research Area, thus adopting the necessary measures to remove obstacles to mobility and cross-border cooperation. The *thirtieth* and *thirty-first,* instead consider the necessity for Member States to adopt integrated policies to ensure that leading academics, researchers and innovators reside and work in Europe and to attract a sufficient number of highly skilled third country nationals to stay in Europe. It also considers scientific cooperation with third countries a common concern. See EU Commission (2010b).

20 See European Parliament, 2012.

21 As stated by the EU Commission (2010a), youth are able to quickly absorb knowledge and develop new ideas and concepts, providing major potential to achieve the Europe 2020 targets. For a review of the literature on the importance of young students' mobility in increasing highly skilled immigration, see Kahanec and Krliková (2011).

3.2 The process of selecting indicators

In order to select the researchers' indicators, we started by considering the 10 previous IISER indicators, which were updated in the MORE[22] study (Table 2).

As noted above, most of these indicators have been further updated in the current study[23] by using several official databases. Other indicators have been updated thanks to data gathered through specific surveys in other WPs in this project.[24] Finally, new indicators taken from other official databases[25] have been proposed in order to offer a more comprehensive "picture" of researchers' mobility and careers.

Table 2: The 10 indicators in the IISER report, grouped into three main categories

A. Indicators on researchers' stock and careers
Indicator 1: Number of researchers in the European Union
Indicator 2: Number of researchers in the training phase and post-docs
B. Indicators on researchers' mobility
Indicator 3: Number of researchers recruited under a permanent contract in R&D
Indicator 4: Average time from graduation to a first regular employment contract in R&D
Indicator 5: Circulation of researchers within Europe
Indicator 6: Number of researchers leaving Europe
Indicator 7: Number of researchers coming into Europe
Indicator 8: Circulation of researchers between public and private sectors
C. Qualitative indicators on researchers' motivation and satisfaction
Indicator 9 & 10: Motivations for R&D careers and satisfaction of researchers with their jobs and careers

Note: This is the original numbering of the indicators in the IISER report. As clarified below, a different numbering is used in this report.
Source: Idea Consult *et al.* (2010)

Compared to previous analyses, the added value of this report consists mainly in bringing together a comprehensive and detailed collection of indicators, which adds both new information compared to earlier exercises and broadens the geographical coverage. In fact, we analyse the 27 EU Member States[26], the Associated Countries[27], the Candidate Countries[28], other OECD Member States [29] and other Third Countries when relevant and data are available.

22 See European Commission (2010a).

23 See IDEA Consult *et al*. (2013).

24 See IDEA Consult *et al*. (2013).

25 Among others, see Australian Bureau of Statistics, Statistics Bureau of Japan, the OECD International Migration Database.

26 Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Ireland, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Hungary, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovak Republic, Finland, Sweden and United Kingdom.

27 Iceland, Liechtenstein, Norway and Switzerland.

28 Montenegro, Croatia, the FYR of Macedonia and Turkey.

29 Among the countries considered are Australia, Canada, Japan, Korea, Mexico, New Zealand, United States, Israel, Brazil, Chile and also China and Russia.

3.3 Set of key researchers' indicators

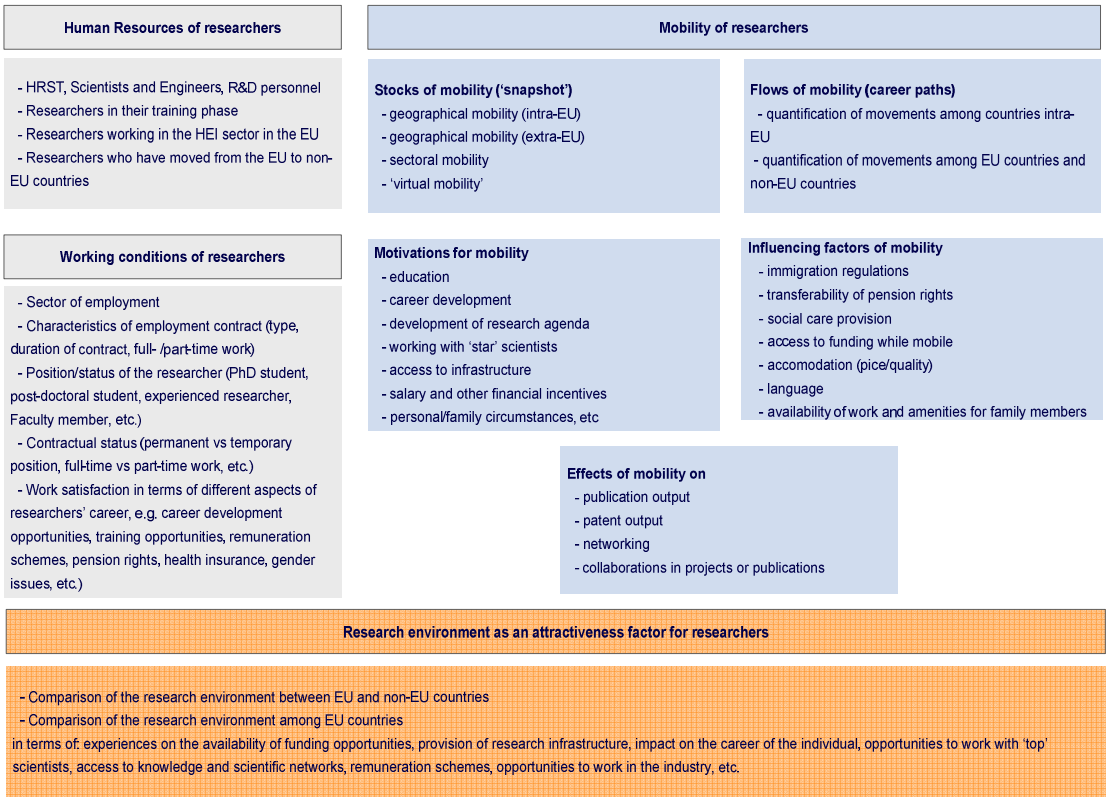
To select the key researchers' indicators we relied on several criteria, the most important of which are:

1. The ability of the indicator to represent the situation relative to the number and the mobility of researchers and their career paths.
2. The availability of data.
3. The indicators produced by other recent or on-going studies in order not to overlap with them (e.g. EUROSTAT/OECD Careers of Doctorate Holders – CDH project; EURODOC survey on Doctoral Candidates; Erawatch IPTS survey).
4. The relevance of the indicator to implement policies that can remove the existing obstacles to researchers' mobility within the European Union and can increase the attractiveness of Europe for non-EU researchers.

As already noted, the key indicators were selected partly from the original IISER indicators, from indicators obtained from specific surveys conducted within other WPs of this project or from other recent studies (e.g. Researchers' Report 2012 and She Figures 2012)[30].

The selected indicators are consequently (re-)structured according to the conceptual framework of the MORE2 project (Figure 1).

Figure 1: Conceptual Framework of the MORE2 study



30 Several studies have recently been undertaken or are being developed on the mobility of researchers, this being one of the most important targets of the ERA project. Some of these studies are illustrated in the Annex to the Report.

The selected key researcher indicators have then been classified in line with this conceptual framework, specifically covering the following aspects:

A. Human Resources of researchers:
Stock of HRST with particular reference to researchers (also those in the training phase), in Europe and in each Member State (Indicators 1-5), focusing on:
- ✓ The stock of researchers in headcount (HC) and full-time equivalents (FTE) according to the most recent available data;
- ✓ The stock of researchers by sector of activity, field of science and gender;
- ✓ The difference between tertiary and doctoral graduates.

B. Mobility of researchers (Indicators 6-16), covering the following issues:
- ✓ Mobility within Europe;
- ✓ Inward Mobility (foreign researchers coming into Europe);
- ✓ Outward Mobility (European researchers leaving Europe);
- ✓ Length of mobility (short versus long term);
- ✓ Sectorial Mobility;
- ✓ Obstacles to mobility.

C. Collaboration and its relation to mobility of researchers (Indicators 17-21), focusing on the following issues:
- ✓ Type of collaboration;
- ✓ Origins of collaboration (as an outcome of mobility experience or other);
- ✓ Virtual mobility.

D. Working Conditions of researchers (Indicators 22-25), especially taking into account:
- ✓ Researchers' career;
- ✓ Obstacles for women in the research profession.

In the following Table 3 we illustrate the indicators and sub-indicators chosen to be updated or newly introduced, grouped into these four main categories. The databases used and the reference period for the updating are also indicated.

Table 3: List of key researchers' indicators and sub-indicators

Main topic	Sub-topic	Indicators	Sub-indicators
A. Human Resource of Researchers	**Stock of researchers**	**Indicator 1:** Number of researchers (HC and FTE)	- in percentage of active population; - by sector of activity; - by occupation ; - by gender;
		Indicator 2: Number of researchers in public sector (higher education and Government)	- as a share of total researcher;
		Indicator 3: Number of researchers in private sector (business enterprise and private non-profit sector)	- as a share of total researcher;
	Number of researchers in their training phase	**Indicator 4:** Number of tertiary education graduates (ISCED 5a-6)	- by field; - by gender;
		Indicator 5: Number of doctoral graduates	- in percentage of population aged 25-34; - by field; - by gender;
B. Mobility of Researchers	**Geographical mobility of doctoral candidates (ISCED 6)** Within Europe	**Indicator 6:** Number and share of doctoral candidates (ISCED 6) with the citizenship of another EU27 in the reporting country in EU27	- as share of total doctoral candidate of the reporting country;
		Indicator 7: Number of doctoral candidates (ISCED 6) with the citizenship of the reporting country in EU27 in all the other member states in EU27	- as share of total doctoral candidate of the reporting country;
	Outside Europe	**Indicator 8:** Number of citizens from the respective country earning doctorates at Universities outside Europe	As a ratio of the number of doctoral degrees awarded at home
		Indicator 9 Number of doctoral candidates in EU27 coming from non-European countries	-By country of origin -by country of destination. -by sector of employment
	Geographical mobility of EU27 HRSTO	**Indicator 10** Number EU27 HRST employed abroad	by country of destination and FOS;
	International Mobility of Higher Education Institutions researchers More than 3 months mobility	**Indicator 11** Share of Higher Education Institutions researchers that have worked abroad for more than 3 months in the last ten years.	By stage of career (R2-R4); gender; children versus no children
	Less than 3 months mobility	**Indicator 12** Share of Higher Education Institutions researchers that have worked abroad for less than 3 months in the last ten years.	- by stage of career (R2-R4); - gender; - children versus no children

	Employer mobility	**Indicator 13** Share of Higher Education Institutions researchers having changed employer at least once in their moves.	- By stage of career (R2-R4); - gender; - children versus no children,
	Inter-sectorial mobility	**Indicator 14** Share of Higher Education Institutions researchers with experience in private sector in the last ten years;	- dual position or not; - if yes, primary or not
	Obstacles or barriers to international mobility	**Indicator 15** Main factors hampering the mobility of researchers across borders in Europe	
	Non-mobility	**Indicator 16** Percentage of non-mobile.	- By gender, - by stage of career
C. Collaboration	**Collaboration**	**Indicator 17** Percentage of researchers having some form of collaboration with researchers from other EU countries as result of previous mobility experience;	by FOS and by sector of activity (HE/research Institutions or private industry)
	Virtual mobility	**Indicator 18** Share of Higher Education Institutions researchers that consider virtual mobility as substitute for short or long term mobility	- by FOS
	Collaboration output	**Indicator 19** Scientific of co-publications of European researchers with an author from another country Per million population	- by country
		Indicator 20 Scientific Publication among the 10% most cited publications worldwide as a percentage of total scientific publication of the country.	
D. Working conditions	**Contract**	**Indicator 21** Share of researchers with different types of contract	- by FOS - by gender
	Position	**Indicator 22** Share of researchers with different positions by FOS and by gender	- by FOS - by gender
	Gender	**Indicator 23** Share of women researcher in Higher Education Institutions by grade (A, B, C)	
		Indicator 24 Glass Ceiling Index	

Source: MORE2 Researcher Indicators (2013)

3.4 Indicators Fiche

In this section, we present each indicator in more detail. In particular, we explain the rationale behind each indicator, the sources for the construction of the indicator, and the release date/date of last revision.

Table 4: Indicators Fiche

Indicator	Rationale	Sources	Date of last revision
Indicator 1: Number of researchers and in percentage of active population, of total employment, by sector of activity, occupation and gender	This indicator makes it possible for each country in EU27, EEA and some of the Candidate countries to know the current situation in terms of stock of researchers. It is useful for comparison with other countries such as US, China etc., but mostly to understand the gap of each EU member country with respect to the national R&D targets established in the EUROPE 2020 strategy.	EUROSTAT	08/02/2013
Indicator 2: Number and share of researchers in public sector (higher education and Government)	This indicator gives information for each Member State about the pattern over time for researchers employed in the public sector and in comparison with those employed in other sectors of the economy. The sub-indicator "by gender", will be a measure of the progress made towards implementing measures of gender equal opportunities	EUROSTAT OECD	08/02/2013
Indicator 3: Number and share of researchers in private sector (business enterprise and private non-profit sector	This indicator gives information for each Member State about the pattern over time of researchers employed in the private sector and in comparison with those employed in other sectors of the economy. The sub-indicator "by gender", will be a measure of the progress towards the implementation of measures of gender equal opportunities	EUROSTAT OECD	08/02/2013
Indicator 4: Number of tertiary education graduates (ISCED 5a-6) by field and gender	This indicator gives the necessary information to understand if the measures adopted in each of the EU27 countries measures to increase the level of education of their population are successful.	UNESCO/OECD/ -EUROSTAT (UOE).	01/03/2013
Indicator 5: Number of doctoral graduates and in percentage of population aged 25-34, by field and gender	This indicator is fundamental in understanding the efficacy of the measures aimed to encourage the research career. The sub-indicator "by gender", will be a measure of the progress of each country to increase the number of women at the top of the scientific career	EUROSTAT	01/03/2013
Indicator 6: Number and share of doctoral candidates (ISCED 6) with the citizenship of another EU27 in the reporting country in EU27	This indicator focuses on country of destination and allows the monitoring of actual mobility of researchers in the first stage of the career, with specific focus on mobility within Europe.	EUROSTAT	01/03/2013
Indicator 7: Number and share of doctoral candidates (ISCED 6) with the citizenship of the reporting country in EU27 in all the other Member States in EU27	This indicator focuses on country of origin and allows the monitoring of actual mobility of researchers in the first stage of the career, with specific focus of mobility within Europe.	EUROSTAT	01/03/2013
Indicator 8: Number of citizens from the respective country earning doctorates at Universities outside Europe	This indicator can be considered a proxy of the risk of "brain drain".	Open Doors, ABS SBJ	12/11/2012

Indicator 9 Number and share of doctoral candidates in EU27 coming from non-European countries	This indicator gives the opportunity to understand the attraction capacity of EU27 countries, particularly in the researchers' training phase	EUROSTAT	01/03/2013
Indicator 10 Number EU27 HRST employed abroad by country of destination and FOS	This indicator gives the opportunity to measure the stock of EU27 HRST employed abroad, in the main destination countries.	OECD International Migration Database	2010
Indicator 11 Share of Higher Education Institutions researchers that have worked abroad for more than 3 months in the last ten years.	This indicator measures international mobility to improve the estimation and understanding of mobility among EU Higher Education Institutions researchers.	MORE2- EU Higher Education Institutions Survey	2012
Indicator 12 Share of Higher Education Institutions researchers that have worked abroad for less than 3 months in the last ten years.	This indicator measures international mobility for a shorter period of time to improve the estimation and understanding of short mobility among EU Higher Education Institutions researchers.	MORE2 - EU Higher Education Institutions Survey	2012
Indicator 13 Share of Higher Education Institutions researchers having changed employer at least once in their moves. .	This indicator measures employer mobility and is helpful to improve the understanding of mobility and mobility profiles of EU Higher Education Institutions researchers	MORE2 - EU Higher Education Institutions Survey	2012
Indicator 14 Share of Higher Education Institutions researchers with experience in private sector in the last ten years	This indicator sheds light on inter-sectorial mobility; one of the concepts of mobility strongly emphasized in the Innovation Union flagship to increase exchange of knowledge between Higher Education Institutions sector and industry sector.	MORE2-EU Higher Education Institutions Survey	2012
Indicator 15 Percentage of Higher Education Institutions non-mobile researchers	This indicator assesses the barriers experienced by the non-mobile EU Higher Education Institutions researchers and therefore aims to improve the understanding thereof and support direction of policy interventions to increase mobility towards European and non-European countries.	MORE2 - EU Higher Education Institutions Survey	2012
Indicator 16 Main factors hampering the mobility of researchers across borders in Europe	This indicator highlights barriers experienced by researchers who were mobile and therefore points to potential fields of policy actions to increase mobility in Europe.	MORE2 - EU Higher Education Institutions Survey	2012
Indicator 17 Percentage of researchers having some form of collaboration with researchers from other EU countries as result of previous mobility experience; by FOS and by sector of activity (HE/research Institutions or private industry)	This indicator is relevant to estimate collaboration and its relation to mobility. It thereby increases knowledge on the relation between mobility and collaboration and supports policy actions in the field to improve knowledge flows within Europe.	MORE2 -EU Higher Education Institutions Survey	2012

Indicator 18 Share of Higher Education Institutions researchers that consider virtual mobility as substitute for short or long term mobility, by FOS	This indicator gives the information about the relevance of ICT technology in reducing physical mobility still maintaining international scientific collaboration.	MORE2-EU Higher Education Institutions Survey	2012
Indicator 19 Percentage of co-publications of European researchers with an author from another country	This indicator can serve as a proxy for scientific output effects of researcher mobility.	Researchers' Report 2012	2011
Indicator 20 Scientific Publication among the 10% most cited publications worldwide as a percentage of total scientific publication of the country.	This indicator can be considered a proxy of the quality of research output in a country, which is strongly influenced by collaboration and exchange of scientific findings with researchers from other countries.	Researchers' Report 2012	2008
Indicator 21 Share of researchers with different types of contract by career stage, FOS and by gender	This indicator provides insights into the contractual status of researchers in different career stages, fields or gender groups and therefore improves understanding of the situation of EU Higher Education Institutions researchers with different characteristics.	MORE2-EU Higher Education Institutions Survey	2012
Indicator 22 Share of researchers with different positions by career stage, FOS and by gender	This indicator provides insights on the position of researchers in different career stages, fields or gender groups and therefore improves understanding of the career paths and opportunities for advancement of EU Higher Education Institutions researchers with different characteristics.	MORE2-EU Higher Education Institutions Survey	2012
Indicator 23 Share of women researcher in Higher Education Institutions by grade (A, B, C)	This indicator measures gender (in)equality and thereby helps to assess and understand the difficulties for women in entering in the research career.	She Figures, 2012	2012
Indicator 24 Glass Ceiling Index	This indicator helps to assess and understand the difficulties for women in progressing in their research career.	She figures, 2012	2012

Source: MORE2 Researcher Indicators (2013)

Part 2 STOCK OF RESEARCHERS

4 RESEARCHERS

4.1 Indicator 1: Stock of Researchers

This section provides an overall picture of Human resources in Sciences and Technology in 2007 and 2010 in the EU, focusing on the number of researchers.

4.1.1 The overall picture in 2007-2010

Table 5 gives a general picture of human resources in Sciences and Technology in the EU27; it provides data on HRST and its subgroups: Scientists and Engineers and Researchers.

The active population (referring to the total labour force, which includes both employed and unemployed persons, expressed in headcount) in the EU27 in 2007 was about 236 million, while total employment was about 219 million. In 2010, the labour force slightly increased (around 240 millions) while total employment fell to around 216 million. In 2007, human resources in Science and Technology accounted for 42.2% of the active population and 45.5% of the total employment; three years later we observe a reduction of approximately 8 percentage points in the share of the active population and about 3 percentage points in the share of total employment.

Those who have successfully completed a tertiary level education in the Science and Technology field (HRSTE) represented 30.5% of the active population in 2007 (down to 24.4% in 2010) and 32.8% of the total employment in 2007 (reduced to 30.5% in 2010). Those who are employed in a Science and Technology occupation (HRSTO) represented slightly lower shares (27.6% and 29.7%, respectively) in 2007. During the subsequent three years the share of the active population reduced to 25.9% while the share of total employment went up to 32.3%. The share of the active population having both completed a tertiary level education and being employed in a Sciences and Technology occupation (HRSTC) was slightly up from 15.8% to 16.2% in the three-year period, while the share of the total employment increased by more, from 17.1 to 20.2%.

Scientists and engineers accounted for 4.8% of the active population and 5.1% of total employment in 2007. The corresponding values in 2010 were 4.7% and 5.9%. Total R&D personnel remained fairly stable as a share both of the active population and of total employment (around 1.5-1.6% in both cases). Researchers in a headcount are estimated to be more than 2.1 million or 0.9% of the active population and 1.0% of the total employment, while the number of researchers in full-time equivalents increased from 2007 to 2010.

These data show that over the period 2007-2010 the major changes relating to human resources in Science and Technology have shown a sharp decline as a share of the active population (around 8 points) and less markedly as a share of total employment (about 3 points).

Table 5: Human Resources in Sciences and Technology, Scientists and Engineers, R&D personnel and Researchers, in EU27 in 2007 and 2010

	Thousands		% of active population		% of total employment	
Year	**2007**	**2010**	**2007**	**2010**	**2007**	**2010**
Active Population	235,842	239,504	100.0	100.0		
Total Employment	219,050	216,422	92.9	90.4	100.0	100.0
Human Resources in Science and Technology[1]	99,570	81,806	42.2	34.2	45.5	42.6
Human Resources in Science and Technology: Education	71,828	58,501	30.5	24.4	32.8	30.5
Human Resources in Science and Technology: Occupation	65,120	62,030	27.6	25.9	29.7	32.3
Human Resources in Science and Technology: Core[2]	37,378	38,725	15.8	16.2	17.1	20.2
Scientists and Engineers - (HC)	11,272	11,286	4.8	4.7	5.1	5.9
Total R&D personnel (HC)[3]	3,438	3,644	1.5	1.5	1.6	1.7
Total R&D personnel (FTE)		2,526		1.1		1.2
Researchers (HC)[3]	2,158	2,320	0.9	1.0	1.0	1.1
Researchers (FTE)	1,448	1,589	0.7	0.7	0.7	0.7

[1] Individuals considered as researchers according to education or occupation
[2] Individuals considered as researchers according both education and occupation
[3] Data refer to 2009
Source: Own calculations based on EUROSTAT data:
a) Active population and total employment: LFS statistics;
b) HRST, HRSTO, HRSTE, HRSTC and S&E: Human Resources in Science and Technology statistics;
c) R&D personnel and Researchers (headcount and full-time equivalents): R&D statistics
d) Total numbers of researchers in headcount and full-time equivalents: R&D personnel at national and regional level statistics

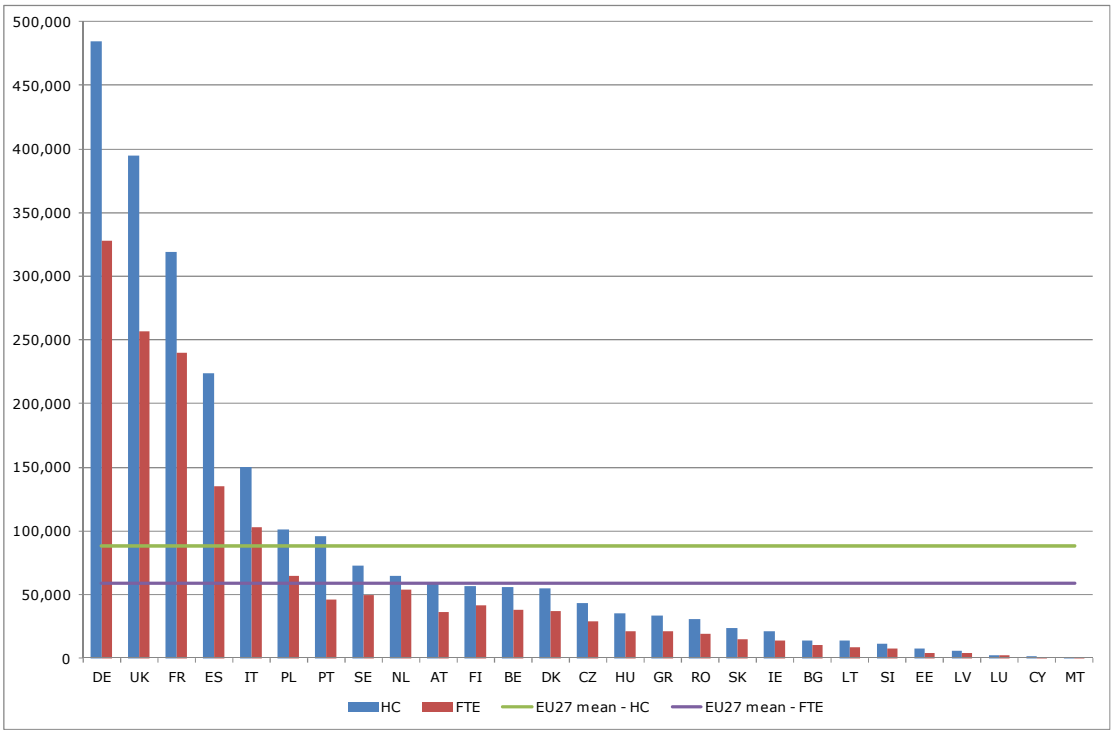
4.1.2 Stock of researchers per country

The number and share of researchers in the active population are among the most important indicators of the role played by scientific and technological research in a country. These indicators actually capture the degree of innovation that characterizes the occupational structure.

The number of researchers in EU27 Member States – calculated both in HC and in FTE – is shown in Figure 2. Looking at FTE, Germany, the UK, France, Italy and Poland are the only countries with more researchers than the mean of the EU27 Member States values. Germany emerges as the country with the highest number of researchers in HC (approximately 500,000), followed by the UK (400,000) and France (300,000). The same countries are those with the highest number of researchers when displayed in FTE. The situation is heterogeneous across the countries when considering the differences between the two indicators (HC and FTE), suggesting profound differences in the type of positions offered to researchers in each EU27 Member State. This aspect is tackled in depth within the MORE 2 HEI Survey[31]. However, absolute values are plagued by size of Member States. In order to compare Member States' performances, it is more fruitful to focus on the share of researchers in the active population.

[31] IDEA Consult et al, 2013b.

Figure 2: Number of researchers in EU27 Member States in 2010[1] (HC and FTE)



[1] As regards FTE, the 2010 value refers to 2007 for Greece. As regards HC, 2010 values refer to 2009 for Belgium, Germany, Luxembourg, Austria and Sweden and to 2005 for Greece.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Unlike the other themes included in the section about "Science and Technology" in the Eurostat database whose updated values (at March 2013) refer to 2010 at most, the most recent data regarding the share of FTE researchers on the active population in EU27 Member States refer to 2011 (Figure 3)[32]. In the EU27, the Nordic countries – Finland (1.5%), Denmark (1.3%) and Sweden (1.0%) plus Luxembourg (1.1%) – have the highest share of researchers (FTE) relative to the active population. The share is the lowest in Romania (0.2%), Cyprus (0.2%), Bulgaria (0.4%) and Poland (0.4%). Most of the countries fall within a range between 0.5% and 0.8%. Apart from Portugal, Southern Europe Member States are characterized by values lower than the EU27 one.

Looking at the time-trends of the share of FTE researchers in the active population (Table 6), an increasing trend in the decade 2000-2010 emerges in all Member States, apart from Latvia, but the growth rates largely differ among Member States, also due to highly heterogeneous starting levels.

As concerns some selected non-EU countries (EEA countries, US, Russia, China, Japan, South Korea), the share of FTE researchers in the active population is higher than the EU27 value in Iceland, Norway, Japan, South Korea and US.

[32] As regards non-EU countries, the most updated data refer to 2010 instead (see Figure 4).

Table 6: Share of researchers in the active population[1] in the period 2000-20112 in EU27 Member States (FTE). Percentage values.

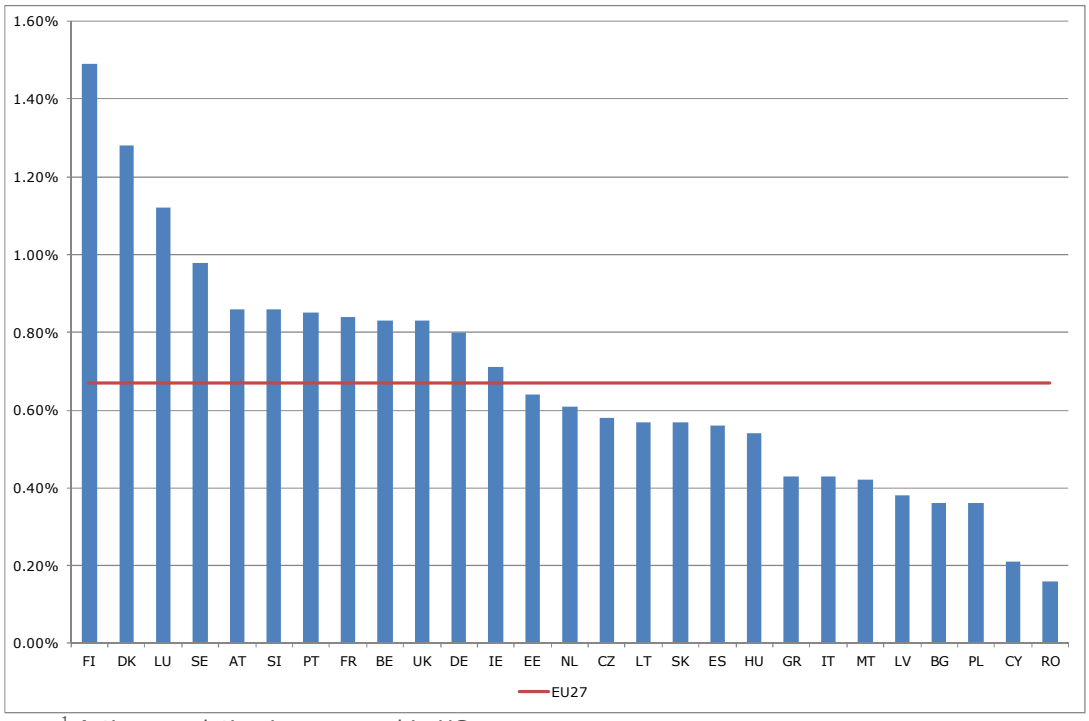
	Shares				% Changes of shares			
	2000	2005	2010	2011	2005/ 2000	2010/ 2005	2010/ 2000	2011/ 2010
EU27	0.49	0.59	0.66	0.67	20.4	11.9	34.7	1.5
BE	0.69	0.72	0.78	0.83	4.3	8.3	13.0	6.4
BG	0.28	0.30	0.32	0.36	7.1	6.7	14.3	12.5
CZ	0.27	0.47	0.55	0.58	74.1	17.0	103.7	5.5
DK	0.67	0.97	1.29	1.28	44.8	33.0	92.5	-0.8
DE	0.65	0.66	0.79	0.80	1.5	19.7	21.5	1.3
EE	0.40	0.50	0.59	0.64	25.0	18.0	47.5	8.5
IE	0.48	0.57	0.67	0.71	18.8	17.5	39.6	6.0
GR	0.32	0.40	0.43	n.a.	25.0	7.5	34.4	n.a.
ES	0.44	0.53	0.58	0.56	20.5	9.4	31.8	-3.4
FR	0.67	0.73	0.84	n.a.	9.0	15.1	25.4	n.a.
IT	0.28	0.34	0.41	0.43	21.4	20.6	46.4	4.9
CY	0.10	0.19	0.21	0.21	90.0	10.5	110.0	0.0
LV	0.35	0.29	0.34	0.38	-17.1	17.2	-2.9	11.8
LT	0.46	0.48	0.53	0.57	4.3	10.4	15.2	7.5
LU	0.89	1.10	1.14	1.12	23.6	3.6	28.1	-1.8
HU	0.35	0.38	0.50	0.54	8.6	31.6	42.9	8.0
MT	0.17	0.30	0.34	0.42	76.5	13.3	100.0	23.5
NL	0.52	0.56	0.61	0.61	7.7	8.9	17.3	0.0
AT	0.62	0.71	0.85	0.86	14.5	19.7	37.1	1.2
PL	0.32	0.36	0.37	0.36	12.5	2.8	15.6	-2.7
PT	0.32	0.38	0.82	0.85	18.8	115.8	156.3	3.7
RO	0.18	0.23	0.20	0.16	27.8	-13.0	11.1	-20.0
SI	0.45	0.52	0.74	0.86	15.6	42.3	64.4	16.2
SK	0.39	0.41	0.56	0.57	5.1	36.6	43.6	1.8
FI	n.a.	1.51	1.55	1.49	n.a.	2.6	n.a.	-3.9
SE	0.90	1.17	1.00	0.98	30.0	-14.5	11.1	-2.0
UK	0.59	0.83	0.82	0.83	40.7	-1.2	39.0	1.2

[1] Active population is expressed in HC

[2] The 2000 data refer to 1999 for Denmark, Sweden and Greece and to 2002 for Malta and Austria; the 2010 value refers to 2007 for Greece

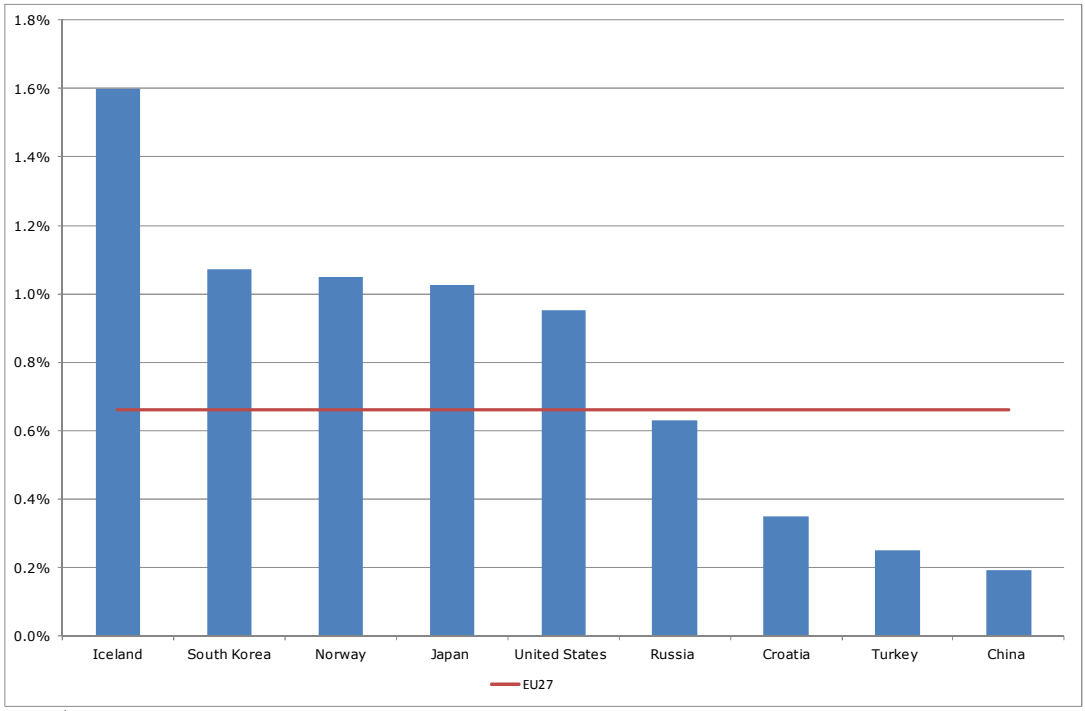
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Figure 3: Share of researchers in the active population[1] in 2011[2] in EU27 Member States (FTE)



[1] Active population is expressed in HC
[2] Data refer to 2010 for France and 2007 for Greece
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Figure 4: Share of researchers in the active population[1] in 20102 in selected non-EU countries (FTE)



[1] Active population is expressed in HC
[2] No FTE data in the selected non-EU countries were available for 2011.
Source: Own calculations based on DG Research and Innovation (2013) "Researchers' Report 2013" and on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Looking at HC, the picture does not change substantially (Figure 5 and Table 7), even if a large decrease in the researchers to active population ration since 2005 to 2010 emerges in Sweden.

Table 7: Share of researchers in the active population[1] in the period 2000-2010[2] in EU27 Member States (HC). Percentage values.

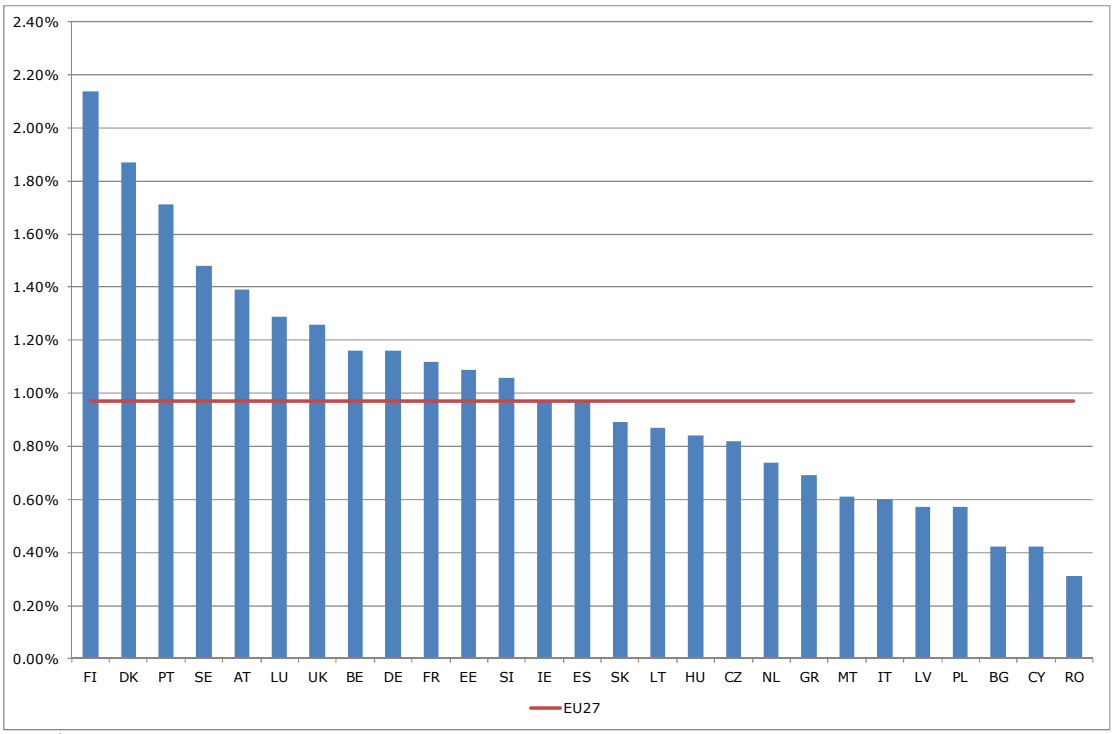
	Shares			% Changes of Shares		
	2000	2005	2010	2005/ 2000	2010/ 2005	2010/ 2000
EU27	n.a.	0.87	0.97	n.a.	11.5	n.a.
BE	n.a.	1.05	1.16	n.a.	10.5	n.a.
BG	0.31	0.36	0.42	16.1	16.7	35.5
CZ	0.59	0.73	0.82	23.7	12.3	39.0
DK	1.01	1.50	1.87	48.5	24.7	85.1
DE	n.a.	0.99	1.16	n.a.	17.2	n.a.
EE	0.69	0.87	1.09	26.1	25.3	58.0
IE	n.a.	0.86	0.97	n.a.	12.8	n.a.
GR	0.65	0.69	n.a.	6.2	n.a.	n.a.
ES	0.69	0.87	0.97	26.1	11.5	40.6
FR	0.82	0.91	1.12	11.0	23.1	36.6
IT	0.43	0.51	0.60	18.6	17.6	39.5
CY	0.25	0.39	0.42	56.0	7.7	68.0
LV	0.56	0.51	0.57	-8.9	11.8	1.8
LT	0.60	0.75	0.87	25.0	16.0	45.0
LU	n.a.	1.20	1.29	n.a.	7.5	n.a.
HU	0.68	0.75	0.84	10.3	12.0	23.5
MT	n.a.	0.61	0.61	n.a.	0.0	n.a.
NL	0.65	0.68	0.74	4.6	8.8	13.8
AT	0.82	1.12	1.39	36.6	24.1	69.5
PL	0.51	0.57	0.57	11.8	0.0	11.8
PT	0.57	0.68	1.71	19.3	151.5	200.0
RO	0.20	0.30	0.31	50.0	3.3	55.0
SI	0.68	0.75	1.06	10.3	41.3	55.9
SK	0.61	0.66	0.89	8.2	34.8	45.9
FI	n.a.	1.94	2.14	n.a.	10.3	n.a.
SE	n.a.	1.75	1.48	n.a.	-15.4	n.a.
UK	n.a.	1.21	1.26	n.a.	4.1	n.a.

[1] Active population is expressed in HC

[2] The 2000 data refer to 1999 for Denmark, Spain and Greece and to 1998 for Austria; the 2005 value refers to 2004 for Austria; 2010 values refer to 2009 for EU27, Belgium, Germany, Luxembourg, Austria and Sweden.

Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Figure 5: Share of researchers in the active population in 2010[1] in EU27 Member States (HC)

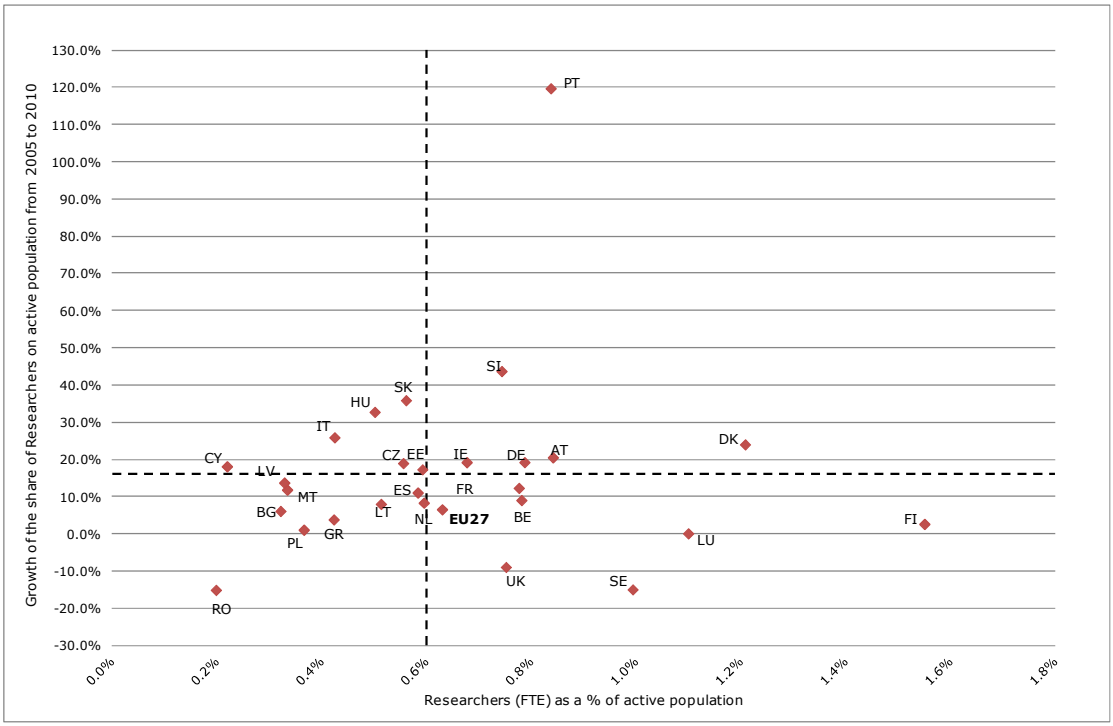


[1] Data refer to 2009 for EU27, Belgium, Germany, Luxembourg, Austria and Sweden and to 2005 for Greece.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

In Figure 6, the share of researchers (FTE) relative to the active population in 2010 (horizontal axis) is associated with the percentage increase of this share in the period 2005-2010 (vertical axis). The countries in which the share increased the most between 2005 and 2010 are Portugal (120%, but the data is plagued by a break in the series in 2008), Slovenia, Slovakia and Hungary (between 30 and 40%). Romania (-19.5%), Sweden (-15.5%) and the UK (-10%) experienced a decline. Regarding Portugal, the very high growth rate could depend on the break in the time series recorded in 2008. However, confirming the increasing trend, it has to be pointed out that the Portuguese share increased by 32% in the period 2005-2007 (i.e. before the break).

Denmark, Austria, Ireland and Germany belong to the group of countries where both the number of researchers as a percentage of the active population and the growth of this share (2005-2010) are equal to or above the EU27 average (upper right quadrant in Figure 6). Finland, Sweden, Luxembourg and UK are above-the-EU27-average level of the share of researchers in the active population but below-the-EU27-average levels of the annual growth of this share (lower right quadrant in Figure 6). Many of the new Member States belong to the group of countries where the share of researchers in the active population is lower than the EU27 unweighted average (i.e. the simple mean of the 27 Member States values). Among them, Romania, Poland along with Malta, also exhibit growth rates below the EU27 unweighted average (lower left quadrant in Figure 6). The rest of the new Member States exhibit below-the-EU27-average shares of researchers in active population but above-the-EU27 average annual growth rates. The EU27 as a whole is characterized by a share slightly higher than the unweighted average and a lower growth rate.

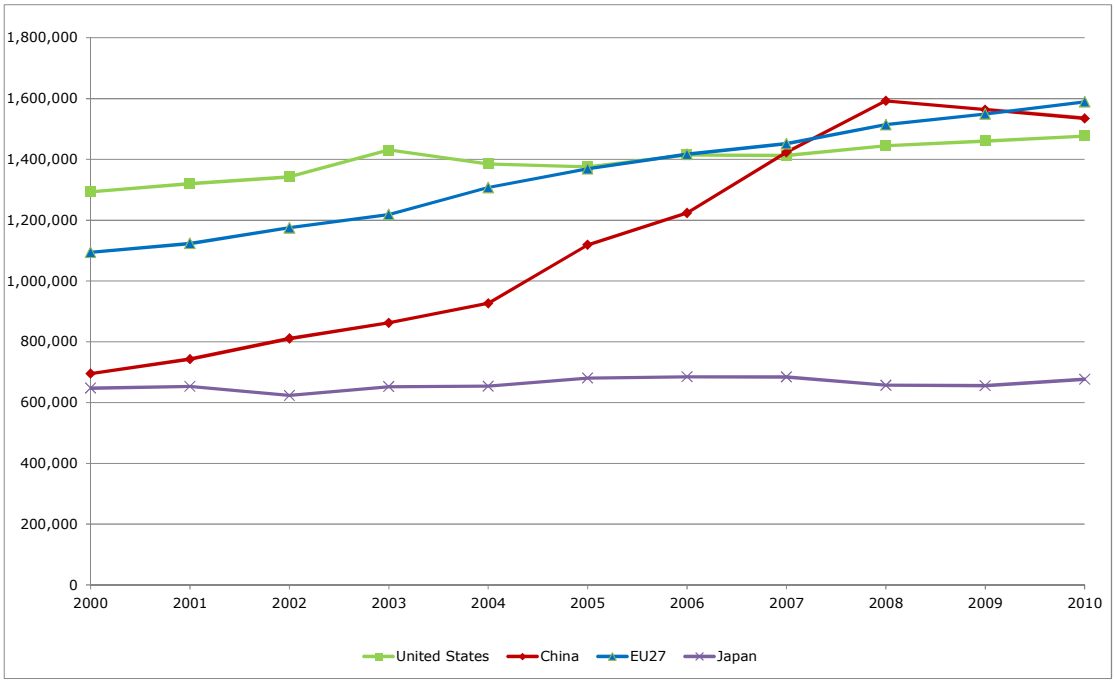
Figure 6: Researchers (FTE) as a share of active population[1] in 2010[2] and growth rate of such share from 2005 to 2010 in EU27 Member States[3]



[1] Active population is expressed in HC
[2] Data refer to 2009 for Greece and France
[3] For Portugal, a break in the time series has been made in 2008.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

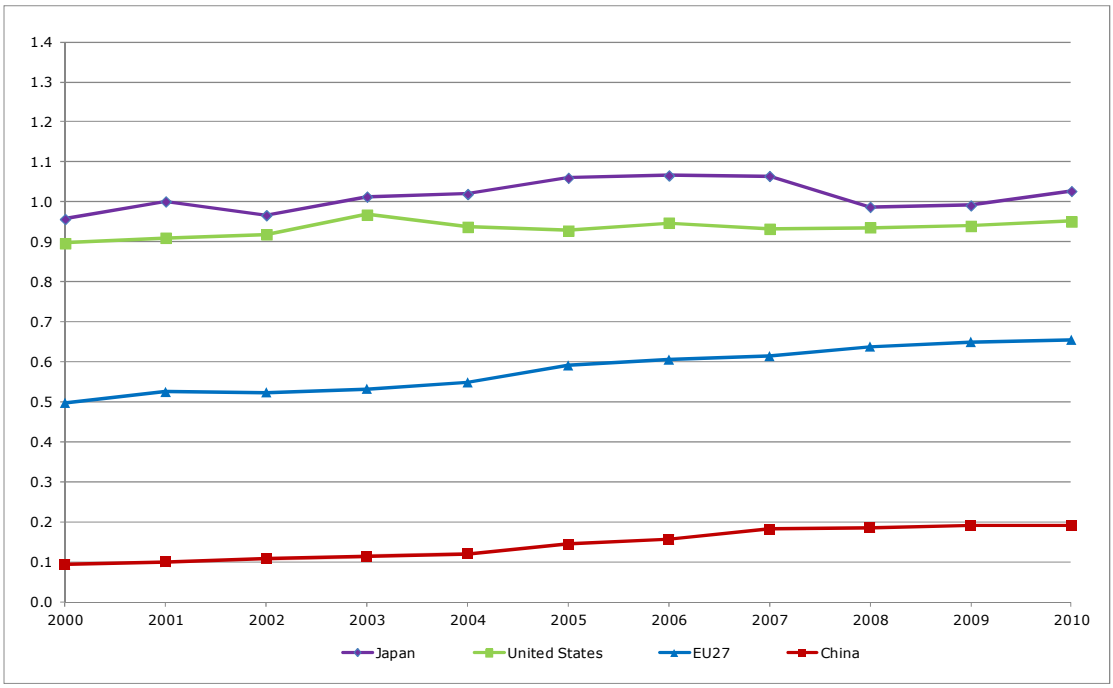
Figure 7 and Figure 8 display, respectively, the trend in the number of researchers in FTE units and as a share of the active population over the period 2000-2010 in EU27, China, Japan and US. Both indicators show an increasing pattern for the EU, especially in units. In absolute term the EU27 has the highest number of researchers in 2010. Not surprisingly, China shows a strongly increasing trend over the period considered, reaching a value of 1.6 million in 2008 and slightly decreasing afterwards. In terms of the active population (Figure 8), the EU27 value is lower than the Japan and US ones, but the gap has reduced in the decade under discussion.

Figure 7: Number of Researchers (FTE) in EU27, China, US and Japan, 2000-2010 (in thousands)



[1] 2009 value for China has been estimated interpolating 2008 and 2010 values.
Source: Own calculations based on DG Research and Innovation (2013) "Researchers' Report 2013" and on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perssci&lang=en

Figure 8: Number of researchers (FTE) as a share of the active population in EU27, China, US and Japan, 2000-2010



Source: Own calculations based on DG Research and Innovation (2013) "Researchers' Report 2013" and on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

4.1.3 Number of researchers by gender

Figure 9 shows the percentage of female researchers in 2010 in EU27 Member States. The percentage for EU27 as a whole is 33%, but differences across countries are marked.

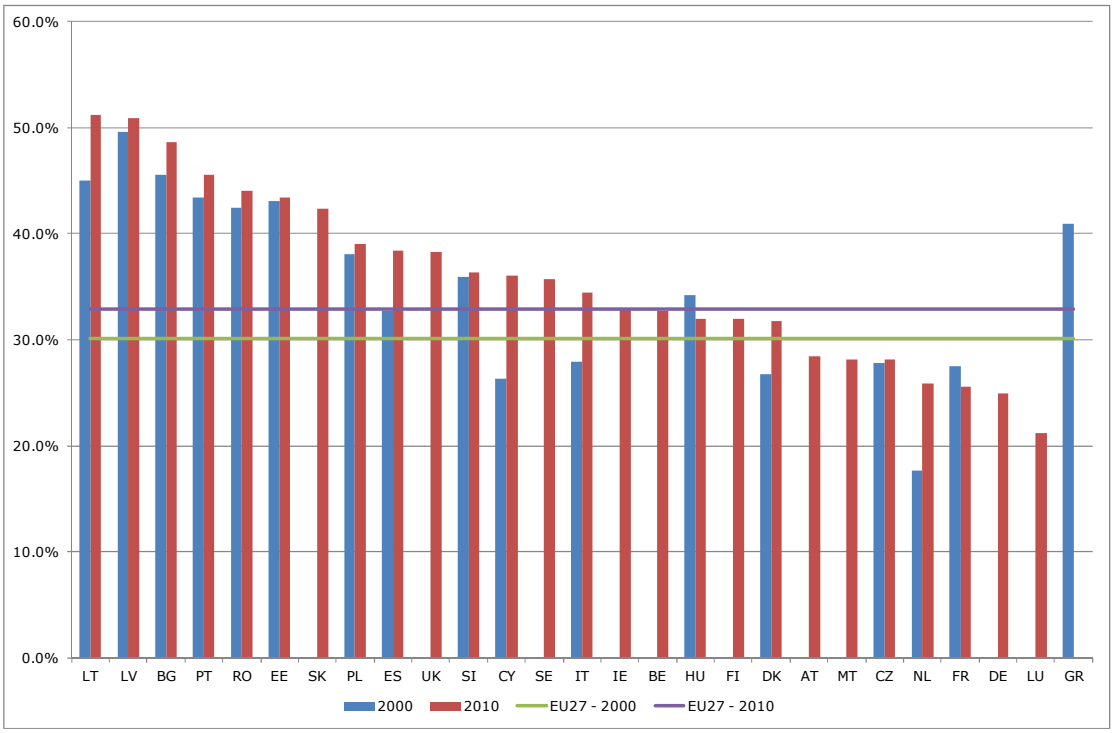
Several Eastern European countries (Latvia, Lithuania, Bulgaria, Estonia Slovakia and Slovenia) are above the EU27 share. By contrast, Germany and France show a percentage of women which is well below the European Union value (around one fourth of total researchers) and Luxembourg has the lowest percentage (only 20%). Nevertheless, it has to be pointed out that in almost all Member States the share of female researchers increased in the period 2000-2010 (Table 8 and Figure 9), but a significant decrease characterize Hungary (-6.5%) and France (-7.0%).

Table 8: Share of female researchers in the period 2000-2010[1] in EU27 Member States (HC)

	Shares			Changes in Shares		
	2000	**2005**	**2010**	**2005/ 2000**	**2010/ 2005**	**2010/ 2000**
EU27	n.a.	31.1%	32.9%	n.a.	5.6%	n.a.
BE	n.a.	29.6%	32.7%	n.a.	10.6%	n.a.
BG	45.6%	45.5%	48.6%	-0.1%	6.7%	6.6%
CZ	27.8%	28.8%	28.1%	3.6%	-2.6%	0.9%
DK	26.8%	29.7%	31.7%	11.0%	6.9%	18.6%
DE	n.a.	21.3%	24.9%	n.a.	16.5%	n.a.
EE	43.1%	40.8%	43.4%	-5.4%	6.4%	0.7%
IE	n.a.	30.3%	33.0%	n.a.	8.8%	n.a.
GR	41.0%	36.4%	n.a.	-11.2%	n.a.	n.a.
ES	32.7%	36.7%	38.4%	12.3%	4.7%	17.6%
FR	27.5%	28.0%	25.6%	1.7%	-8.5%	-7.0%
IT	27.9%	32.3%	34.5%	16.1%	6.6%	23.7%
CY	26.3%	32.6%	36.0%	24.1%	10.6%	37.2%
LV	49.6%	51.5%	50.8%	4.0%	-1.4%	2.5%
LT	45.0%	48.6%	51.2%	8.2%	5.3%	14.0%
LU	n.a.	18.2%	21.2%	n.a.	16.5%	n.a.
HU	34.2%	34.2%	32.0%	-0.1%	-6.4%	-6.5%
MT	n.a.	26.2%	28.1%	n.a.	7.2%	n.a.
NL	n.a.	21.0%	25.9%	n.a.	23.1%	n.a.
AT	n.a.	23.6%	28.4%	n.a.	20.4%	n.a.
PL	38.1%	39.3%	39.0%	3.1%	-0.6%	2.5%
PT	43.4%	44.4%	45.5%	2.2%	2.6%	4.9%
RO	42.5%	45.3%	44.0%	6.7%	-2.8%	3.7%
SI	35.9%	34.8%	36.3%	-3.2%	4.5%	1.1%
SK	n.a.	41.5%	42.4%	n.a.	2.2%	n.a.
FI	n.a.	30.2%	31.9%	n.a.	5.6%	n.a.
SE	n.a.	35.8%	35.7%	n.a.	0.0%	n.a.
UK	n.a.	35.7%	38.3%	n.a.	7.5%	n.a.

[1] Data for 2010 refer to 2009 for EU27, Denmark, Germany, Netherlands, Luxembourg, Belgium, Austria and Sweden and are missing for Greece. Data for 2000 refer to 1999 for Denmark, Greece and Spain. The 2005 value for Austria refers to 2004.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

Figure 9: Share of female researchers in 2000 and 2010[1] in EU27 Member States (HC)



[1] Data refer to 2009 for EU27, Denmark, Germany, Netherlands, Luxembourg, Belgium, Austria and Sweden. Data for 2009 are missing for Greece. 2000 data refers to 2003 for EU27, to 1999 for Denmark, Greece and Spain. Member States are ranked according to 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

4.1.4 Number of researchers by sector of activity

If we look at the percentage breakdown by sector (as shown in Table 9 and in

The trend in the number of researchers (FTE) working in the public sector in EU27 Member States has been upwards during the period 2000-2010 (Table 11). Likewise, the number of researchers employed in the Business Enterprise sector increased over the period 2000-2010, measured both in headcount or as full-time equivalents (Table 12), showing the effort that EU27 countries are putting towards reaching one of the Europe 2020 priorities, namely: "Smart growth-developing and economy based on knowledge and innovation".

Table 10), in almost all European countries the majority of researchers work in Universities or the business enterprise sector. Indeed, Luxembourg, France, Germany and Finland have a number of industrial researchers greater than or equal to those working in all other sectors. The presence of non-university researchers in the Government sector is significant only in the Eastern European countries (e.g. Slovenia, Bulgaria, Czech Republic, Poland), having public research institutions with strong traditions. As far as the private non-profit sector is concerned, we only find a small percentage of researchers working in this sector in Portugal, Cyprus and Italy.

Table 9: Number of researchers in EU27 Member States by sector of activity as a share of total researchers employed, 2010 (FTE)

	Business enterprise sector	Government sector	Higher education sector	Private non-profit sector	Total
BE	44.4%	7.4%	47.4%	0.7%	100.0%
BG	14.0%	52.4%	32.9%	0.7%	100.0%
CZ	43.3%	21.4%	34.6%	0.7%	100.0%
DK	61.1%	3.1%	35.3%	0.5%	100.0%
DE	56.7%	15.8%	27.6%	0.0%	100.0%
EE	31.4%	13.4%	53.4%	1.7%	100.0%
IE	55.6%	4.0%	40.4%	0.0%	100.0%
GR	29.9%	10.5%	58.9%	0.7%	100.0%
ES	33.7%	18.1%	48.0%	0.2%	100.0%
FR	58.4%	11.2%	29.3%	1.2%	100.0%
IT	37.0%	16.9%	42.0%	4.0%	100.0%
CY	22.1%	11.3%	58.2%	8.4%	100.0%
LV	16.2%	16.3%	67.5%	0.0%	100.0%
LT	14.4%	17.1%	68.5%	0.0%	100.0%
LU	55.4%	25.0%	19.7%	0.0%	100.0%
HU	48.1%	23.6%	28.3%	0.0%	100.0%
MT	56.9%	5.7%	37.4%	0.0%	100.0%
NL	49.5%	13.0%	37.5%	0.0%	100.0%
AT	62.3%	4.5%	32.5%	0.7%	100.0%
PL	18.2%	21.0%	60.7%	0.1%	100.0%
PT	22.9%	5.3%	61.8%	10.1%	100.0%
RO	29.6%	28.3%	41.7%	0.5%	100.0%
SI	44.0%	26.4%	29.4%	0.2%	100.0%
SK	12.7%	19.8%	67.2%	0.3%	100.0%
FI	55.3%	11.0%	32.7%	1.0%	100.0%
SE	61.7%	3.8%	34.4%	0.0%	100.0%
UK	32.8%	3.4%	62.3%	1.5%	100.0%
EU27	***44.9%***	***12.5%***	***41.6%***	***1.1%***	***100.0%***

Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perssci&lang=en

The trend in the number of researchers (FTE) working in the public sector in EU27 Member States has been upwards during the period 2000-2010 (Table 11). Likewise, the number of researchers employed in the Business Enterprise sector increased over the period 2000-2010, measured both in headcount or as full-time equivalents (Table 12), showing the effort that EU27 countries are putting towards reaching one of the Europe 2020 priorities, namely: "Smart growth-developing and economy based on knowledge and innovation[33]".

[33] European Commission, 2010a. One of the targets to measure the Member States' progress towards this priority is the investment of 3% of each Member States' own GDP in R&D.

Table 10: Number of researchers in EU27 Member States by sector of activity in selected non-EU countries, as a share of total researchers employed, 2010[1] (FTE)

	Business enterprise sector	Government sector	Higher education sector	Private non-profit sector	Total
Iceland	39.3%	19.1%	39.3%	2.2%	100.0%
Norway	47.3%	16.9%	35.8%	0.0%	100.0%
Switzerland	41.1%	1.9%	57.0%	0.0%	100.0%
Croatia	18.0%	29.5%	52.3%	0.1%	100.0%
FYR	6.6%	45.5%	47.8%	0.0%	100.0%
Turkey	39.4%	9.5%	51.2%	0.0%	100.0%
Russia	47.8%	32.8%	19.1%	0.3%	100.0%
United States	77.8%	3.3%	18.9%	0.0%	100.0%
China	65.9%	16.8%	17.3%	0.0%	100.0%
Japan	76.5%	4.9%	17.4%	1.2%	100.0%
South Korea	76.5%	7.5%	14.9%	1.1%	100.0%

[1] Data refer to 2009 for Iceland, China and Japan, 2008 for Switzerland
Source: Own calculations based on DG Research and Innovation (2013) "Researchers' Report 2013" and on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persci&lang=en

Table 11: Number of researchers (FTE) in the public sector (Government sector and higher education sector) in EU27 in 2000, 2005 and 2010

	Numbers			% Changes		
	2000	2005	2010	2005/ 2000	2010/ 2005	2010/ 2000
Total Public sector	570,380	727,195	838,831	27.5%	15.4%	47.1%
Higher education sector	399,616	547,230	640,276	36.9%	17.0%	60.2%
Government sector	170,764	179,965	198,555	5.4%	10.3%	16.3%

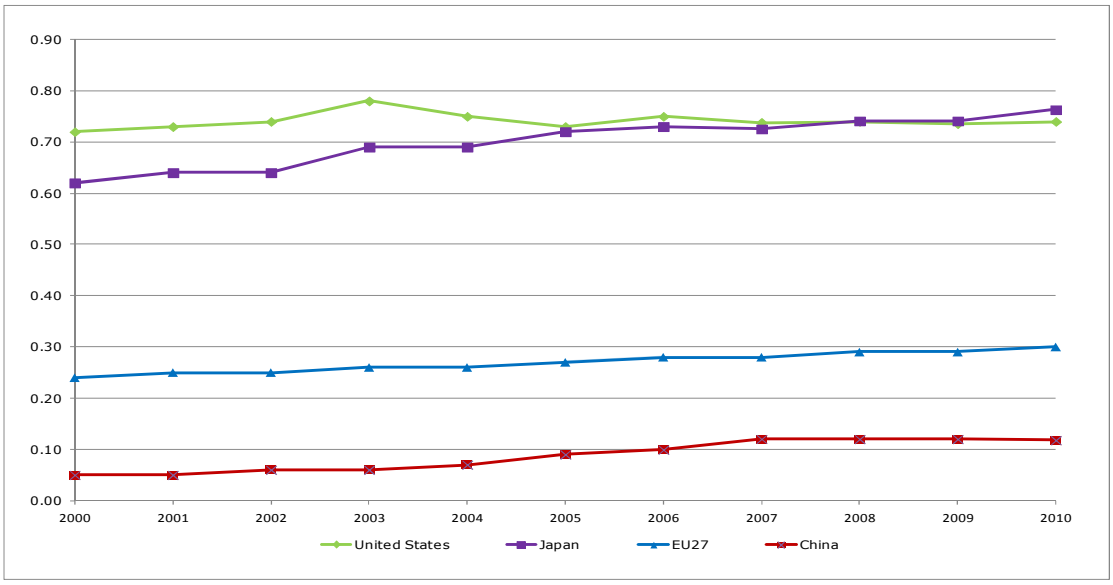
Source: Own calculations based on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

Table 12: Number of business researchers in EU27, 2000, 2005 and 2010

	Numbers			% Changes		
	2000	2005	2010	2005/ 2000	2010/ 2005	2010/ 2000
HC	587,539	705,566	874,550	20.1%	24.0%	48.8%
FTE	524,844	625,055	706,935	19.1%	13.1%	34.7%

Source: Own calculations based on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

Figure 10: Number of business researchers (FTE) as a share of the active population in EU27, China, US, Japan and OECD, 2000-2010



Source: Own calculations based on DG Research and Innovation (2013) "Researchers' Report 2013" and on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc &lang=en

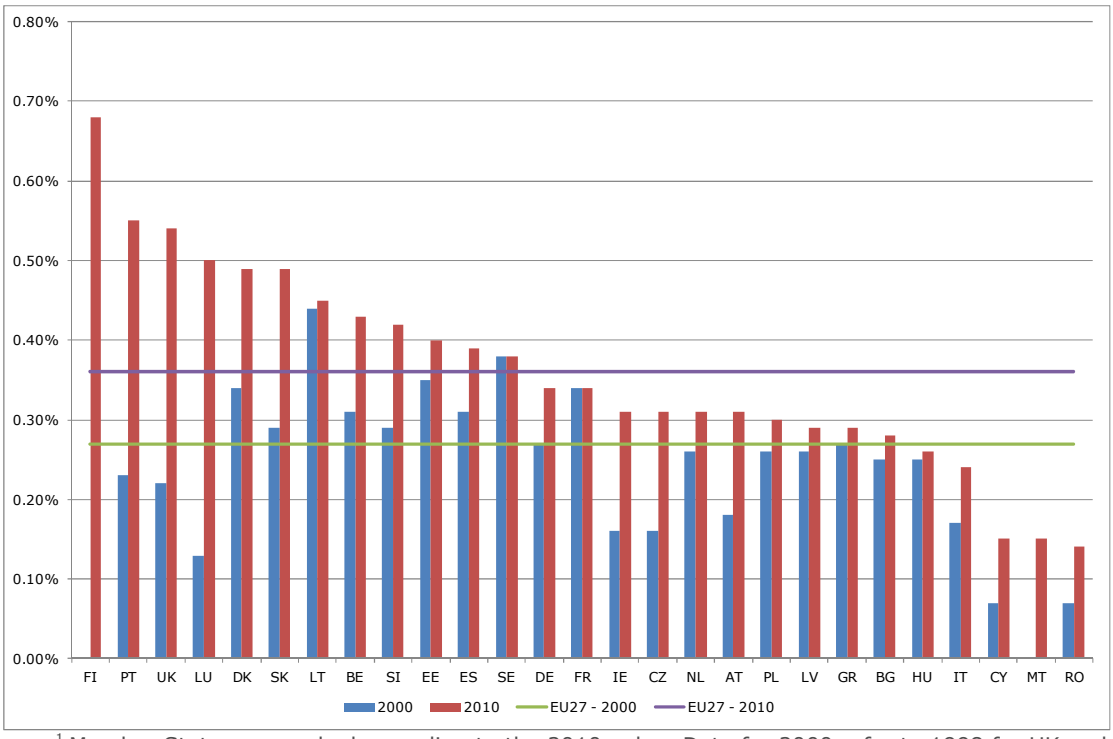
On the other hand, the dynamics of the number of business researchers as a percentage of the active population is much flatter in the EU27 (the share slightly changed from 0.2% to 0.3%; Figure 10). The same applies to the US, but not to Japan and China where the share increased in the period 2000-2010. Information about the share of researchers by sectors is detailed further in indicators 2 and 3.

4.2 Indicator 2: Stock of researchers in the public sector

The number of researchers (FTE) working in the public sector as a share of the active population has significantly grown in the EU27 over the period 2000-2010 (Figure 11). Apart from France and Sweden, where the ratios remained stable, all Member States have been characterized by an increasing trend. Figure 11 also shows that the six countries with the highest shares of public sector researchers are Finland, Portugal, UK, Luxembourg, Denmark and Slovakia.

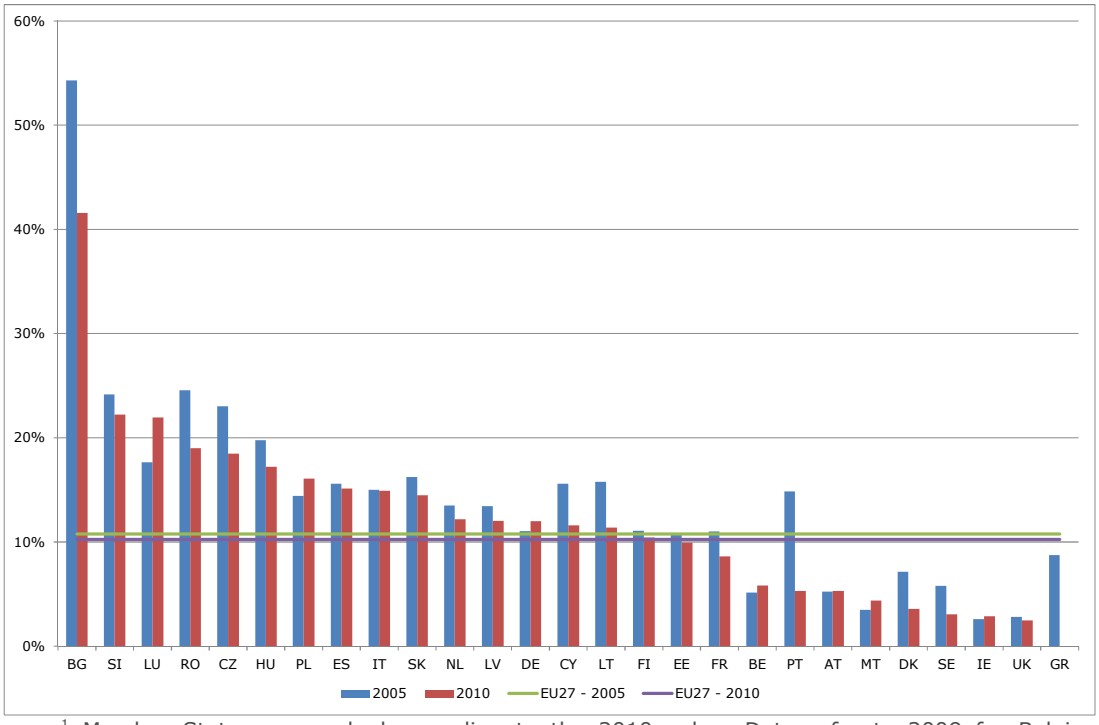
Figure 12 and Figure 13 show, respectively, the number of researchers in HC as a share of total researchers employed in the Government sector and in the Higher Education Sector in 2005 and 2010. Taken together, the researchers employed in the Government and in Higher Education Institutions represent the majority of researchers, as confirmed also when looking at FTE (Figure 14) .

Figure 11: Number of researchers (FTE) in the public sector as a share of the active population in EU27 Member States, 2000-2010[1]



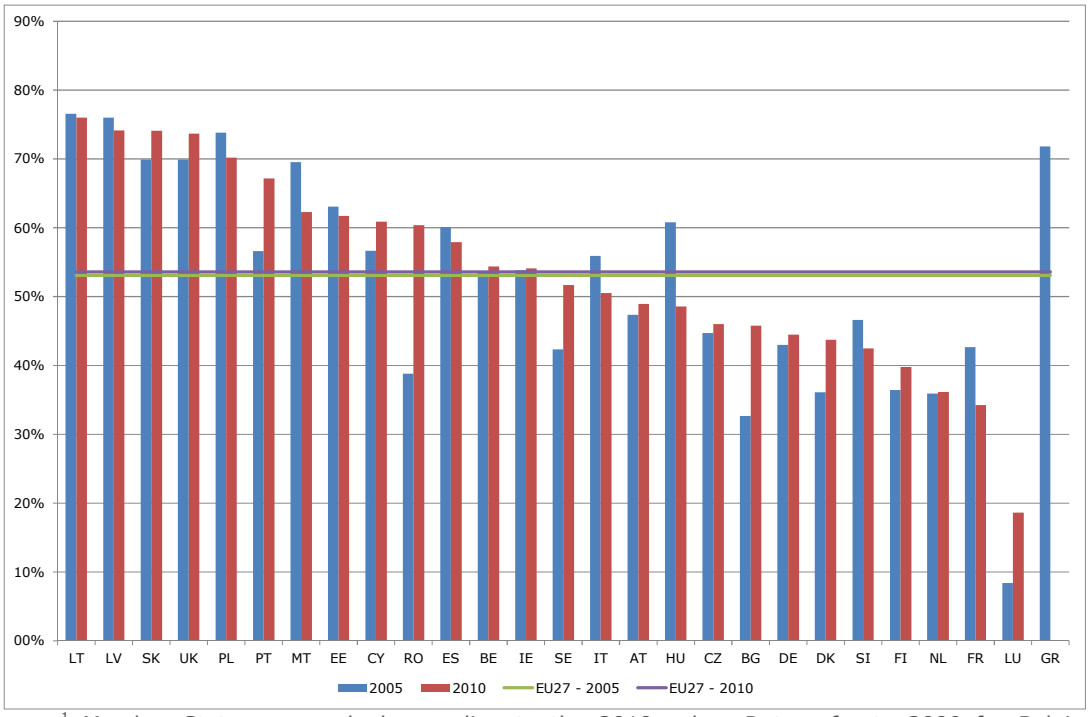
[1] Member States are ranked according to the 2010 value. Data for 2000 refer to 1998 for UK and Austria, to 1999 for Greece and Sweden. The 2010 value for Greece refers to 2007.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perslf&lang=en

Figure 12: Researchers in the Government sector as % of total employed researchers, in EU27 Member States in 2005 and 2010[1] *(HC)*



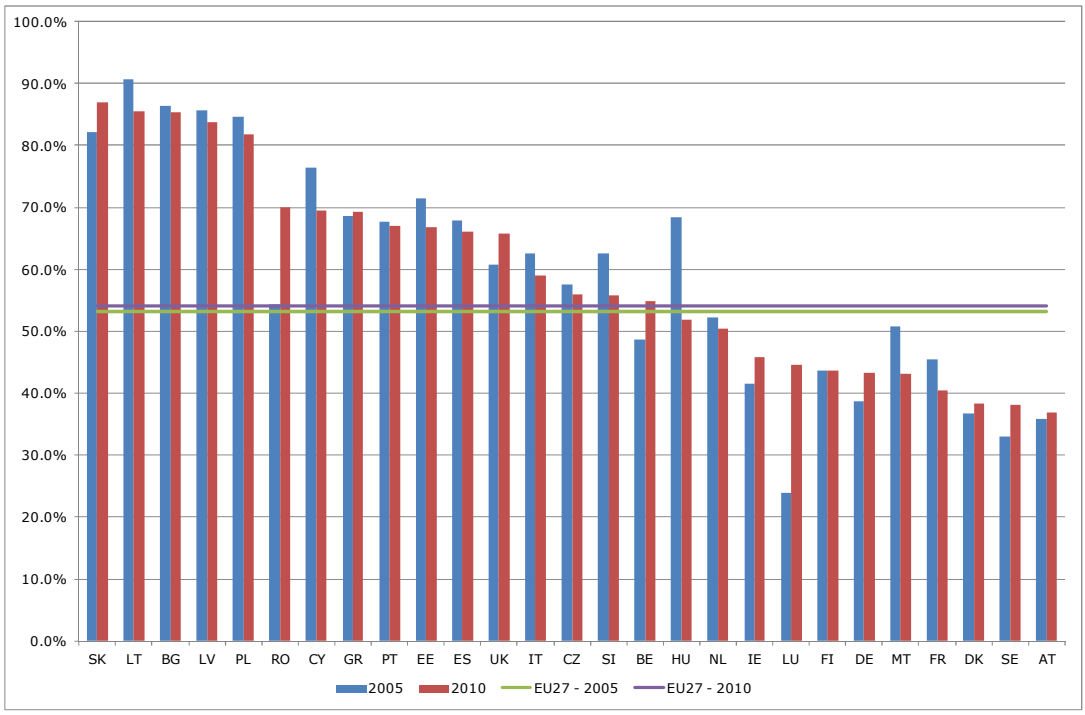
[1] Member States are ranked according to the 2010 value. Data refer to 2009 for Belgium, Germany, Luxembourg, Austria and Sweden. The 2010 value for Greece is missing (the oldest data refers to 2005).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_perssci&lang=en

Figure 13: Researchers in the higher education sector as % of total employed researchers, in EU27 Member States in 2005 and 2010[1] (HC)



[1] Member States are ranked according to the 2010 value. Data refer to 2009 for Belgium, Germany, Luxembourg, Austria and Sweden. The 2010 value for Greece is missing (the oldest data refers to 2005).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

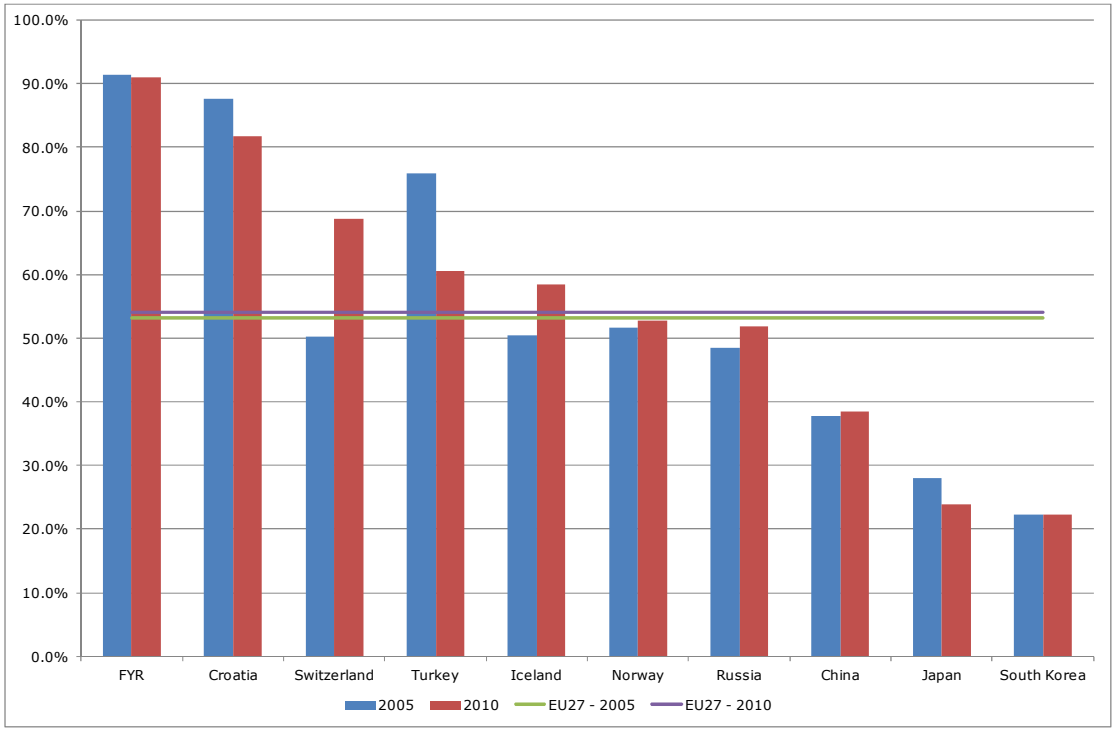
Figure 14: Researchers in the public sector (higher education and Government) as % of total employed researchers, in EU27 Member States in 2005 and 2010[1] (FTE)



[1] Member States are ranked according to the 2005 value. The 2010 value refers to 2007 for Greece
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

Concerning non-EU countries (US data are not available), the share of researchers working in the public sector is well below the EU27 value in China, Japan and South Korea (Figure 15).

Figure 15: Share of researchers in the public sector (higher education and Government) as % of total employed researchers in the country, in selected non-EU countries in 2005 and 2010[1] (FTE)



[1] Member States are ranked according to the 2005 value. The 2005 value refers to 2004 for Switzerland. The 2010 values refer to 2008 for Switzerland and to 2009 for China, Japan, Iceland and FYR. Data for US are missing.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

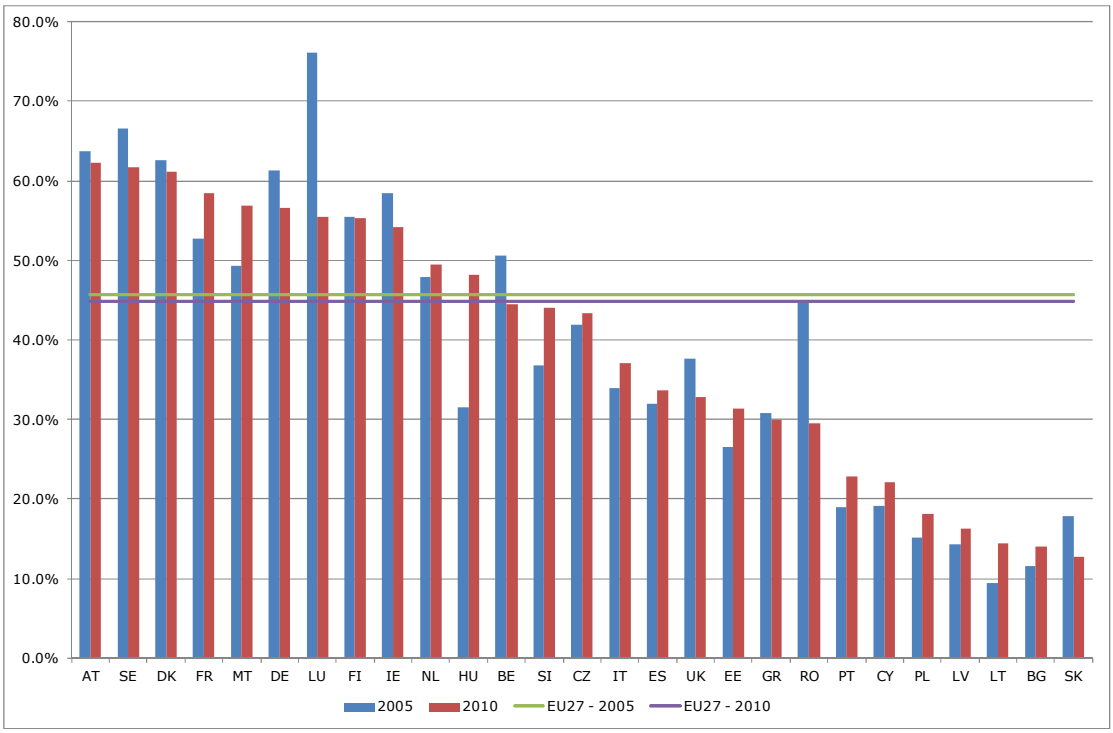
4.3 Indicator 3: Stock of researchers in the private sector

As already shown, in the EU27 Member States the share of researchers working in the private sector (business and non-profit) is much smaller than the share of those working in the public sector. Indeed, as shown in Table 11 and in Table 12, there were around 707,000 researchers (measured in FTE) in the private sector, against 839,000 in the public sector in 2010.

In the large majority of EU27 countries the share of researchers employed in the business enterprise sector is less than 50% of total when measured in FTE (Figure 16). However, this indicator shows an increasing trend over the period 2005-2010 in some Member States (e.g. France, Slovenia, Italy and Hungary).

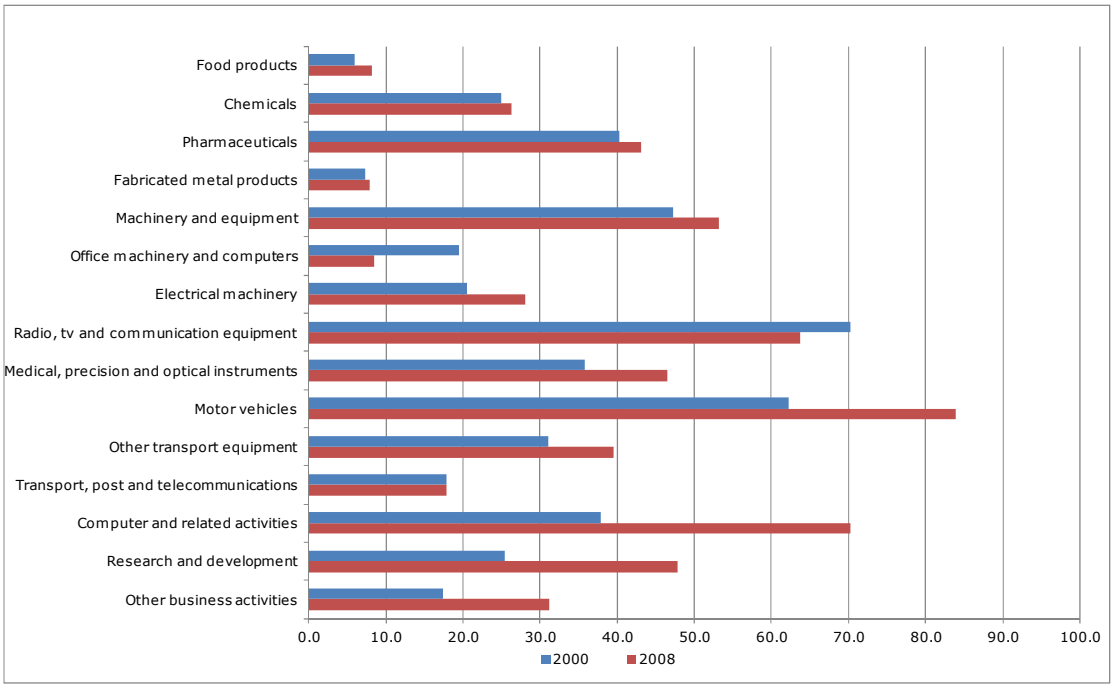
Focusing on a greater level of detail, Figure 17 shows that in 2008 (the more recent year for which data are available) the majority of the private sector researchers (in HC) were employed in the motor vehicles sector (more than 80,000); in the computer sector (about 70,000); in radio, TV and communications (more than 60,000); in the machinery and equipment sector (more than 50,000) and in the pharmaceutical (about 40,000), i.e. in the NACE Rev.1 sectors usually considered as the most innovative sectors. It is also worth noting that in the large majority of sectors this indicator increased over the period 2000-2008.

Figure 16: Researchers in the business enterprise sector as % of total employed researchers, in EU27 Member States in 2005 and 2010[1] (FTE)



[1] The 2010 value refers to 2007 for Greece.
Source: Own calculations based on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_persocc&lang=en

Figure 17: Number of business researchers (FTE) in EU27 by selected NACE sectors (in thousands), 2000-2008



Source: Own calculations based on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rd_p_bempocc&lang=en

5 RESEARCHERS IN THE TRAINING PHASE

5.1 Indicator 4: Number of graduates with academic orientation

In order to forecast the potential number of Research and Development personnel in coming years, the important indicators are the number of graduate students at tertiary level of education (ISCED 5 and 6), particularly those with tertiary education academically oriented (ISCED 5A)[34] and those with doctoral degrees (ISCED 6)[35].

Where possible, we compare EU27 as a whole, each EU Member State and other selected non-EU countries[36] on the basis of the following indicators:

a. the total numbers;
b. the numbers and the shares of graduates by field of science;
c. the numbers and the shares of graduates by gender.

5.1.1 Tertiary graduates (ISCED 5A and 6)

5.1.1.1 Total tertiary graduates (ISCED 5A and 6)

The number of tertiary graduates (ISCED 5A and 6) increased considerably in Europe as well as in the US during the period 2000-2010 (Figure 18). The increase has been less pronounced in Japan. In EU27 the number of graduates continues to be higher than in the other two competitor countries. In particular, the number of EU27 graduates was 50% higher than those recorded by the US in 2010.

Poland is the EU Member State with the highest number of graduates in ISCED 5A and 6 in 2010, followed by the UK, France, Italy and Germany (Table 13). These are also the most populous countries. Likewise, the countries with the lowest absolute number of tertiary graduates in 2010 are the smallest Member States. i.e. Lithuania, Latvia Slovenia, Estonia, Malta, Cyprus and Luxemburg. In the period 2000-2010 a large increase in the number of tertiary graduates (ISCED 5A and 6) has characterized all Member States, apart from Hungary and France where the growth rate has been lower than 20% (Table 13).

Distinguishing ISCED 5A graduates in the two subgroups (Table 14) the picture is more heterogeneous, especially as regards the 2005-2010 time trends. The growth rates of graduates in these sub-groups have actually been affected by reforms implemented in some countries that modified the academic curricula offered (e.g. Italy, Spain and Germany), then affecting the numbers of those

[34] The International Standard Classification of Education (ISCED-97) was adopted internationally to make different degrees comparable, depending on the different school systems adopted in different countries. It defines ISCED level 5A programmes as those programmes at tertiary level which are "largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programmes and profession with high skills requirements".

[35] The ISCED 6 level are second stage of tertiary education programme leading to an advanced research qualification and are devoted to advanced study and original research and are not based on course-work only.

[36] The timeline was chosen to show the most comparable data which are currently available.

attaining ISCED 5A1 and 5A2 levels. Apart from Portugal, Poland and Finland the number of doctoral graduates (ISCED 6) increased everywhere between 2005 and 2010 (Table 14).

Table 13: Number and rate of growth of tertiary graduates (ISCED 5A & 6) in EU27 Member States in the period 2000-2010[1]

	Numbers				% Changes			
	2000	2005	2009	2010	2005/ 2000	2010/ 2005	2010/ 2000	2010/ 2009
EU27	2,283,958	3,191,172	3,566,832	3,748,577	39.7%	17.5%	64.1%	5.1%
BE	32,074	39,683	58,418	60,481	23.7%	52.4%	88.6%	3.5%
BG	41,615	42,004	51,034	53,594	0.9%	27.6%	28.8%	5.0%
CZ	29,877	45,670	88,483	95,214	52.9%	108.5%	218.7%	7.6%
DK	33,390	42,195	42,955	46,736	26.4%	10.8%	40.0%	8.8%
DE	n.a.	240,092	407,463	433,726	n.a.	80.6%	n.a.	6.4%
EE	3,940	7,467	7,353	7,555	89.5%	1.2%	91.8%	2.7%
IE	27,362	39,483	43,393	45,290	44.3%	14.7%	65.5%	4.4%
GR	n.a.	41,951	n.a.	44,305	n.a.	5.6%	n.a.	n.a.
ES	n.a.	206,153	224,920	247,100	n.a.	19.9%	n.a.	9.9%
FR	367,536	463,296	411,482	435,353	26.1%	-6.0%	18.5%	5.8%
IT	195,273	379,887	387,250	378,550	94.5%	-0.4%	93.9%	-2.2%
CY	515	805	2,424	2,762	56.3%	243.1%	436.3%	13.9%
LV	n.a.	21,965	21,447	21,587	n.a.	-1.7%	n.a.	0.7%
LT	17,141	28,135	32,469	32,360	64.1%	15.0%	88.8%	-0.3%
LU	n.a.	n.a.	n.a.	852	n.a.	n.a.	n.a.	n.a.
HU	59,210	68,570	61,427	61,858	15.8%	-9.8%	4.5%	0.7%
MT	1,679	2,028	2,700	2,808	20.8%	38.5%	67.2%	4.0%
NL	77,238	106,684	126,931	130,569	38.1%	22.4%	69.0%	2.9%
AT	17,050	24,770	40,991	44,070	45.3%	77.9%	158.5%	7.5%
PL	n.a.	495,504	568,620	619,623	n.a.	25.0%	n.a.	9.0%
PT	n.a.	56,871	75,720	78,529	n.a.	38.1%	n.a.	3.7%
RO	n.a.	145,739	310,677	305,220	n.a.	109.4%	n.a.	-1.8%
SI	5,815	7,476	9,655	11,494	28.6%	53.7%	97.7%	19.0%
SK	n.a.	34,415	74,752	76,154	n.a.	121.3%	n.a.	1.9%
FI	30,686	40,573	44,870	50,890	32.2%	25.4%	65.8%	13.4%
SE	37,884	52,279	52,148	53,480	38.0%	2.3%	41.2%	2.6%
UK	393,400	560,782	538,279	575,197	42.5%	2.6%	46.2%	6.9%

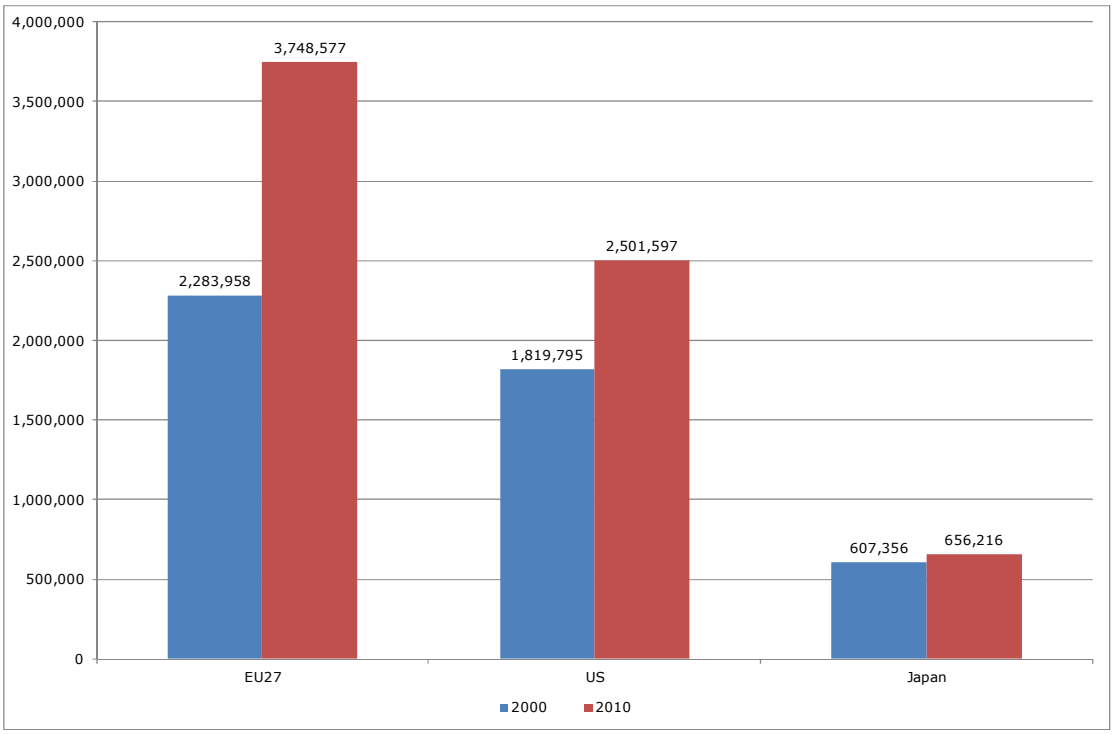
[1] The 2005 value refers to 2006 for Spain and the 2009 value refers to 2008 for Greece. Missing values in 2000 are due to the missed information about the number of ISCED 5A2 graduates.
The EUROSTAT data for Italy relative to graduate students in ISCED 5A2 and ISCED 6 in 2009 and 2010 were missing. We linearly interpolated these missing data from the 2008 and 2011 data.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Table 14: Number and rate of growth of tertiary graduates by ISCED groups (ISCED 5A & 6) in EU27 Member States in the 2005 and 2010[1]

	2005			2010			% Growth 2010/2005		
	5A1	5A2	6	5A1	5A2	6	5A1	5A2	6
EU27	2,272,947	816,742	101,483	2,581,204	1,063,968	103,405	13.6%	30.3%	1.9%
BE	24,682	13,400	1,601	25,949	32,406	2,126	5.1%	141.8%	32.8%
BG	25,501	15,975	528	29,548	23,450	596	15.9%	46.8%	12.9%
CZ	38,415	5,347	1,908	60,525	32,461	2,228	57.6%	507.1%	16.8%
DK	31,222	10,018	955	32,073	13,275	1,388	2.7%	32.5%	45.3%
DE	197,770	16,370	25,952	369,059	38,628	26,039	86.6%	136.0%	0.3%
EE	5,801	1,535	131	4,837	2,543	175	-16.6%	65.7%	33.6%
IE	26,486	12,187	810	27,084	16,984	1,222	2.3%	39.4%	50.9%
GR	35,219	5,484	1,248	32,723	9,690	1,892	-7.1%	76.7%	51.6%
ES	195,946	3,305	6,902	197,890	40,514	8,696	1.0%	1125.8%	26.0%
FR	273,523	180,195	9,578	298,606	124,081	12,666	9.2%	-31.1%	32.2%
IT	291,304	78,979	9,604	211,770	155,086	11,694	-27.3%	96.4%	21.8%
CY	670	130	5	2,010	722	30	200.0%	455.4%	500.0%
LV	15,031	6,820	114	15,339	6,116	132	2.0%	-10.3%	15.8%
LT	19,177	8,637	321	22,279	9,675	406	16.2%	12.0%	26.5%
LU	n.a.	n.a.	n.a.	702	92	58	n.a.	n.a.	n.a.
HU	57,162	10,339	1,069	49,380	11,203	1,275	-13.6%	8.4%	19.3%
MT	1,546	477	5	2,046	750	12	32.3%	57.2%	140.0%
NL	90,033	13,772	2,879	91,389	35,444	3,736	1.5%	157.4%	29.8%
AT	21,908	634	2,228	32,143	9,427	2,500	46.7%	1386.9%	12.2%
PL	287,607	202,175	5,722	355,220	261,086	3,317	23.5%	29.1%	-42.0%
PT	50,319	2,402	4,150	54,011	21,591	2,927	7.3%	798.9%	-29.5%
RO	97,649	44,219	3,871	191,151	109,305	4,764	95.8%	147.2%	23.1%
SI	6,197	910	369	9,616	1,413	465	55.2%	55.3%	26.0%
SK	27,085	6,308	1,022	42,027	31,249	2,878	55.2%	395.4%	181.6%
FI	37,688	930	1,955	32,946	16,194	1,750	-12.6%	1641.3%	-10.5%
SE	46,046	3,455	2,778	40,702	9,407	3,371	-11.6%	172.3%	21.3%
UK	368,960	176,044	15,778	350,179	206,262	18,756	-5.1%	17.2%	18.9%

[1] The 2005 value refers to 2006 for Spain. Data for Italy have been estimated (see note to
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 18: Number of tertiary graduates (ISCED 5A and 6) in EU27, Japan and US in 2000 and 2010



Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.1.1.2 Tertiary graduates (ISCED 5A and 6) by field of science

The distribution of graduates among the different fields of science in the EU Member States is quite heterogeneous, as shown in Table 15. However, in almost all the Member States, Social Science and Business is the field with the highest number of students. A similar picture applies to the selected non-EU countries (Table 16).

Table 15: Distribution of tertiary graduates (ISCED 5A & 6) in EU27 Member States by field of science in 2010[1]

	Teacher training and education science	Humanities and arts	Social sciences, business and law	Science, mathematics and computing	Engineering, manufacturing and construction	Agriculture and veterinary	Health and welfare	Services	Unknown or not specified	Total
BE	12.3%	11.1%	30.7%	5.2%	10.9%	2.4%	22.3%	2.0%	3.1%	100.0%
BG	5.5%	6.8%	51.6%	4.7%	15.2%	1.9%	6.7%	7.6%	0.0%	100.0%
CZ	15.1%	7.5%	34.1%	9.2%	14.2%	3.4%	8.9%	4.5%	3.1%	100.0%
DK	7.6%	13.2%	32.7%	8.3%	11.1%	1.6%	22.6%	2.9%	0.0%	100.0%
DE	9.3%	16.4%	22.4%	12.6%	13.0%	1.5%	21.5%	3.0%	0.3%	100.0%
EE	7.7%	12.8%	37.6%	9.8%	10.7%	1.9%	11.0%	8.5%	0.0%	100.0%
IE	8.5%	12.0%	30.8%	11.2%	12.0%	1.3%	15.6%	5.1%	3.5%	100.0%
GR	8.8%	13.2%	30.3%	12.1%	15.4%	4.5%	12.6%	3.1%	0.0%	100.0%
ES	14.4%	8.6%	26.6%	8.6%	16.0%	1.7%	15.3%	7.9%	0.8%	100.0%
FR	1.5%	10.3%	41.6%	10.6%	15.6%	1.5%	14.9%	4.0%	0.0%	100.0%
IT	7.0%	14.7%	32.1%	7.5%	14.6%	1.7%	15.4%	4.1%	2.9%	100.0%
CY	10.7%	10.1%	49.0%	6.9%	6.4%	0.1%	7.6%	9.2%	0.0%	100.0%
LV	8.3%	7.2%	54.3%	5.0%	9.3%	0.9%	9.3%	5.7%	0.1%	100.0%
LT	11.5%	7.2%	45.8%	5.0%	16.2%	1.9%	9.6%	2.9%	0.0%	100.0%
LU	20.8%	7.9%	51.4%	8.1%	5.6%	0.0%	6.1%	0.0%	0.0%	100.0%
HU	11.5%	12.5%	39.9%	6.8%	8.8%	2.4%	8.9%	9.2%	0.0%	100.0%
MT	10.5%	18.9%	38.3%	9.4%	6.9%	0.5%	12.6%	2.9%	0.0%	100.0%
NL	13.4%	9.0%	37.6%	6.1%	7.9%	1.5%	18.7%	5.3%	0.6%	100.0%
AT	12.1%	8.6%	34.0%	9.7%	19.2%	1.8%	10.9%	3.5%	0.1%	100.0%
PL	16.3%	8.0%	42.6%	6.8%	8.9%	1.7%	8.9%	6.2%	0.5%	100.0%
PT	8.7%	8.2%	29.3%	6.5%	18.3%	1.6%	20.8%	6.5%	0.0%	100.0%
RO	1.5%	8.3%	60.0%	4.8%	12.3%	1.6%	8.8%	2.7%	0.0%	100.0%
SI	7.5%	6.2%	44.3%	5.5%	15.6%	2.8%	8.7%	9.4%	0.0%	100.0%
SK	13.7%	6.6%	31.9%	7.9%	12.9%	1.9%	19.2%	5.9%	0.0%	100.0%
FI	6.1%	13.4%	23.0%	7.8%	24.0%	2.2%	18.4%	5.1%	0.0%	100.0%
SE	14.8%	6.3%	24.1%	7.4%	18.4%	1.1%	24.9%	3.1%	0.0%	100.0%
UK	11.0%	15.7%	30.9%	12.7%	9.6%	0.9%	16.8%	1.4%	0.9%	100.0%
EU27	***9.6%***	***11.5%***	***35.7%***	***9.2%***	***12.7%***	***1.6%***	***15.0%***	***4.2%***	***0.5%***	***100.0%***

[1] Member States are shown in the EU official alphabetical order. Data for France refer to 2009. Data for Italy have been estimated (see note to Table 13).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Table 16: Distribution of tertiary graduates (ISCED 5A & 6) in selected non-EU countries by field of science in 2010[1]

	Teacher training and education science	Humanities and arts	Social sciences, business and law	Science, mathematics and computing	Engineering, manufacturing and construction	Agriculture and veterinary	Health and Welfare	Services	Unknown	Total
HR	3.1%	16.0%	42.7%	9.5%	13.2%	3.9%	5.5%	6.0%	0.0%	100.0%
IS	19.6%	9.8%	37.7%	6.5%	9.3%	0.5%	15.5%	1.1%	0.0%	100.0%
NO	17.6%	8.6%	29.4%	7.1%	9.0%	0.7%	22.4%	5.0%	0.4%	100.0%
CH	11.6%	12.6%	37.2%	10.1%	11.2%	1.1%	13.1%	2.2%	0.9%	100.0%
FYR	10.6%	13.6%	39.2%	12.1%	8.0%	2.4%	7.6%	6.5%	0.0%	100.0%
TR	19.9%	6.4%	47.9%	7.4%	8.4%	2.2%	6.2%	1.6%	0.0%	100.0%
US	11.7%	14.9%	40.2%	8.9%	6.1%	1.0%	11.5%	5.7%	0.0%	100.0%
JP	6.2%	17.2%	33.9%	4.6%	18.8%	3.4%	7.5%	2.4%	5.9%	100.0%

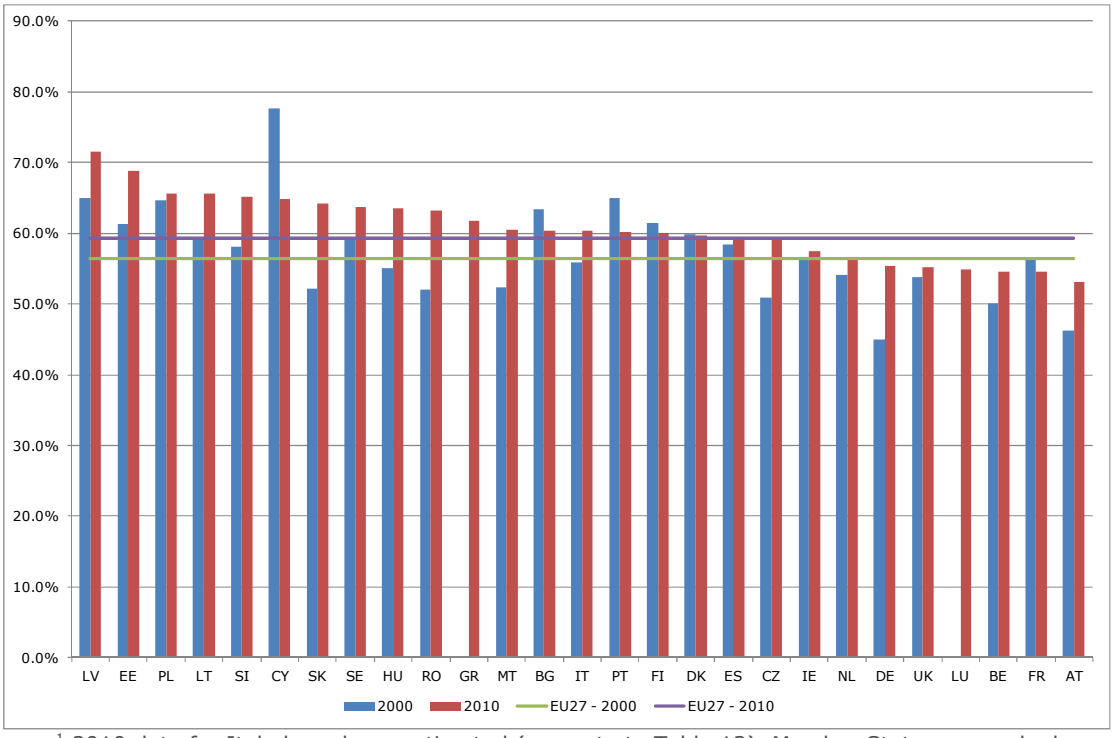
[1] Member States are shown in the EU official alphabetical order.
Source: Own calculations based on EUROSTAT data

5.1.1.3 Tertiary graduates (ISCED 5A and 6) by gender

Throughout the European Union and in the majority of the selected non-European Union countries (Figure 19), the share of female tertiary graduates is higher than 50% - over 70% in Latvia in 2010. The countries with the highest share of female graduates are mostly the new Member States such as Latvia, Estonia, Poland, Lithuania and Slovenia. 17 out of 27 Member States have a share of between 70% and 60%. Only 10 have a share of female tertiary graduates between 60 and 50%. Furthermore, the female share increased everywhere from 2000 to 2010, apart from few cases (Cyprus, Bulgaria, Portugal, Finland and France).

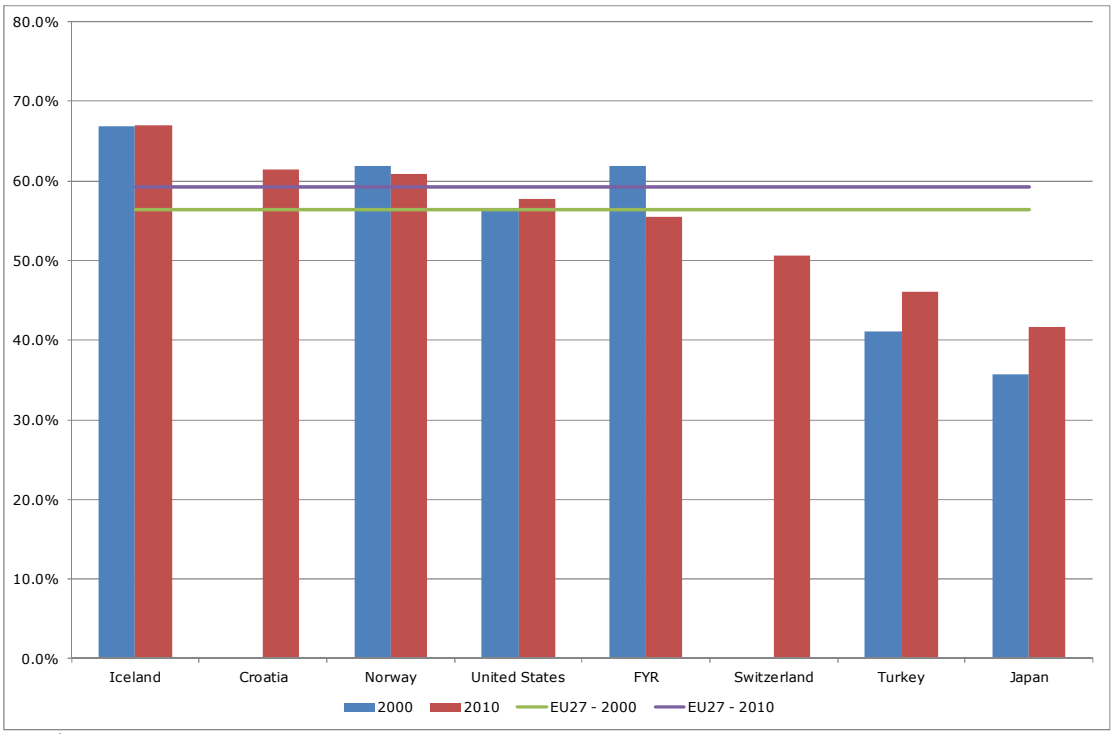
In the non-EU countries, the picture is different. Figure 20 shows that only Iceland has more than 60% of women graduates in 2010, and Turkey and Switzerland have less than 50%. The United States have just above 50% while Japan remains below this threshold.

Figure 19: Share of female tertiary graduates (ISCED 5A & 6) in EU27 Member States in 2000 and 2010[1]



[1] 2010 data for Italy have been estimated (see note to Table 13). Member States are ranked according to the 2010 value.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 20: Share of female tertiary graduates on total graduates (ISCED 5A & 6) in selected non-EU countries in 2000 and 2010[1]



[1] Countries are ranked according to the 2010 value.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

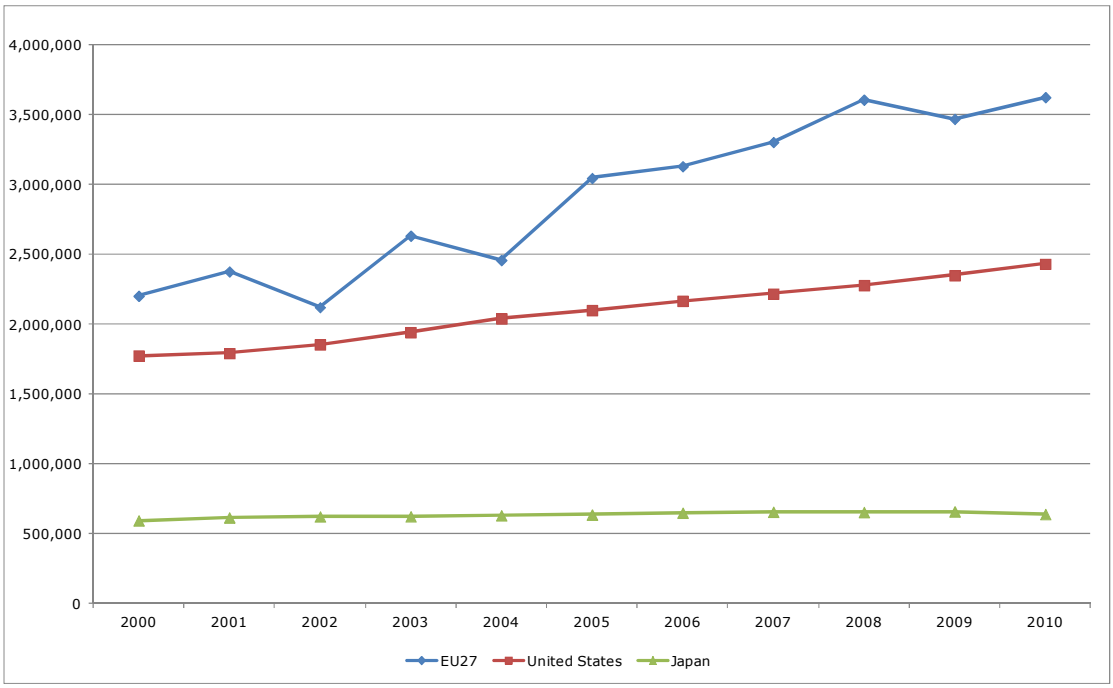
5.1.2 Tertiary graduates with academic orientation (ISCED 5A)

5.1.2.1 Total tertiary graduates (ISCED 5A) with academic orientation

In EU27, more than 3.6 million tertiary degrees with an academic orientation (ISCED 5A) were awarded in 2010 (Figure 21). This is a much higher number than in Japan (640,000) and also higher than in US (around 2.5 million). In EU 27 countries, the average annual growth rate during the decade was 5.1%. Also seen from this perspective, the EU performance is better than the US (3,2%) and much better than Japan (0,7%). Between 2000 and 2010, the total number of such degrees went up by 26,000 in Japan; by 800,000 in US and by almost 1,500,000 in EU.

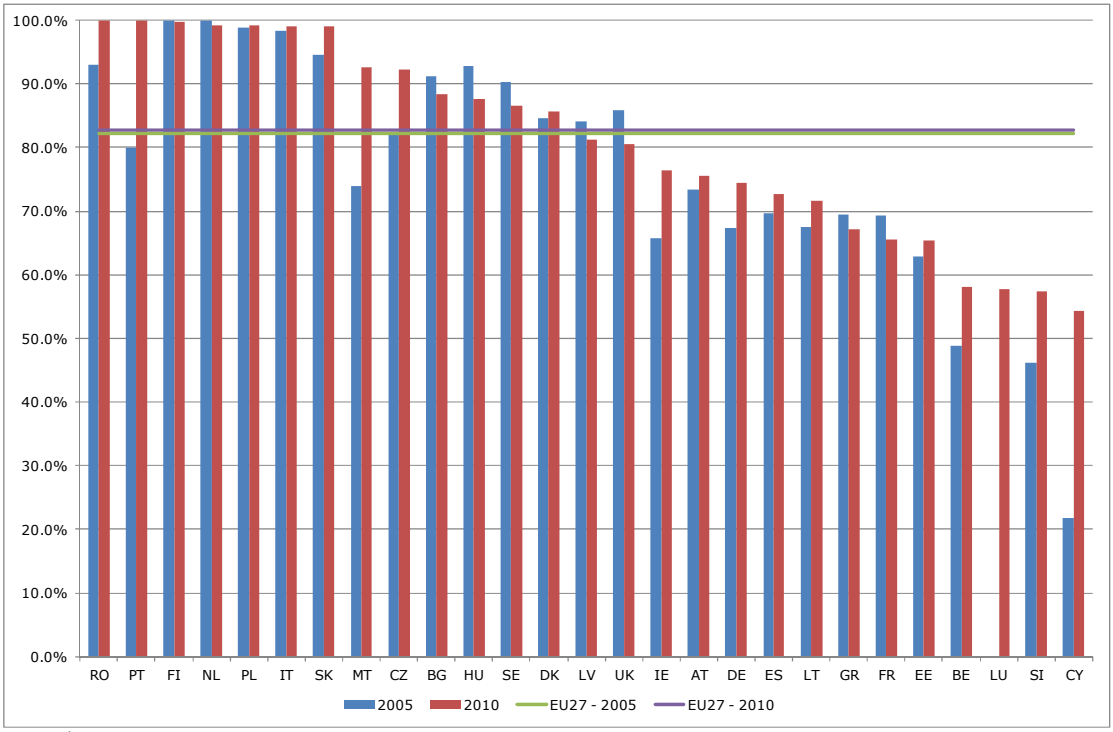
As shown in Figure 22, in 7 EU Member States – Romania, Portugal, Finland, Poland, Italy, the Netherlands and Slovakia – almost all ISCED 5 graduates attains an academic degree (i.e. an ISCED 5A level), whereas the share of non-academic ISCED 5B graduates is relatively high in Belgium, Luxembourg, Slovenia and Cyprus.

Figure 21: Number of tertiary degrees with academic orientation (ISCED 5A) in EU27, Japan and US, 2000-2010



Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad4&lang=en

Figure 22: Number of tertiary degrees with academic orientation (ISCED 5A) as a share of total tertiary degrees (ISCED 5) in EU27 Member States in 2005 and 2010[1]



[1] 2010 data for Italy have been estimated (see note to Table 13). Member States are ranked according to the 2010 value.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.1.2.2 Tertiary graduates (ISCED 5A) by field of science

The distribution of tertiary graduates among the fields of education in EU27 remained stable in the period 2000-2010 (Table 17). Only two disciplines underwent a significant increase in their shares: Health and Welfare (from 9% in 2000 to 12% in 2010) and Social Sciences, Business and Law (from 35% to 38%). A 1% decrease occurred in the shares of Science, Mathematics and Computing (from 11% to 10%), Engineering, Manufacturing and Construction (from 13% to 12%) and Agriculture and Veterinary (from 2% to 1%).

As shown in Figure 23, the share of Science and Engineering degrees in the total number of degrees with academic orientation is 1 percentage point less in EU27 in 2010 (22%) with respect to 2000 (23%). In both US and Japan, the decline was slightly larger (2%): their shares in 2010 were 13% and 23%, respectively.

Table 17: Distribution of tertiary degrees with academic orientation (ISCED 5A) by field of science in EU27 as share of total ISCED 5A degrees, 2000-2010 (in %)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Social sciences, business and law	36.7	36.5	36.4	36.2	37.5	38.3	37.2	37.0	37.7	38.1	38.3
Humanities and arts	13.7	13.1	11.8	12.5	11.9	12.6	13.3	13.2	13.2	12.8	12.7
Health and welfare	9.7	9.6	11.4	10.5	11.3	11.2	11.6	12.0	12.0	12.1	12.0
Engineering, manufacturing and construction	13.1	12.9	13.0	13.2	12.3	11.8	11.8	11.9	11.7	12.3	12.2
Teacher training and education science	11.5	12.3	12.6	12.0	12.6	11.0	11.4	11.1	10.6	9.8	9.9
Science, mathematics and computing	10.9	10.6	9.5	10.6	9.5	10.2	10.0	10.0	9.9	9.6	9.7
Services	2.5	3.1	3.1	3.3	3.1	3.3	3.2	3.4	3.4	3.7	3.7
Agriculture and veterinary	1.9	1.7	2.0	1.7	1.8	1.6	1.5	1.6	1.5	1.5	1.5

Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

When looking at Member States (Table 18), the highest shares of graduates in Science and Engineering in 2010 (over 25%) characterize Austria, Germany, Greece, France, Finland and Sweden, while shares lower than 15% are observed in Latvia, the Netherlands and Malta.

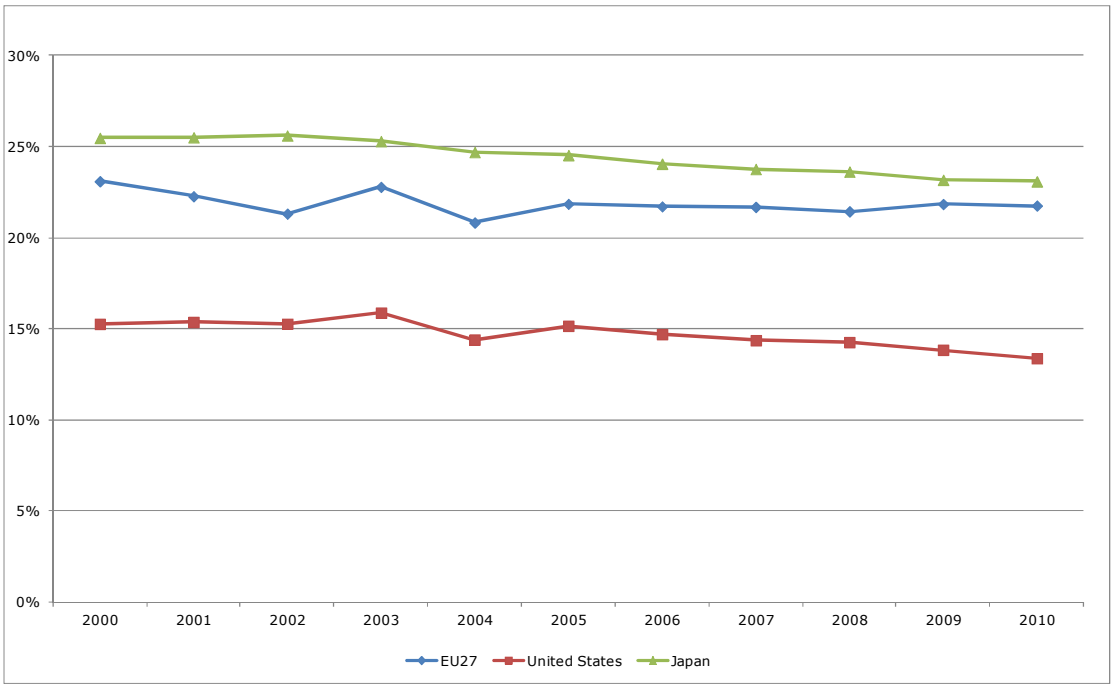
Furthermore, it has to be pointed out that at the EU27 level the shares of both those graduating in Science, Mathematics and Computing and in Engineering, Manufacturing and Construction decreased since 2000 up to 2010, but the Member States performances are mixed (Figure 24 and Figure 25).

Table 18: Number of tertiary degrees in Science, Mathematics and Computing and in Engineering, Manufacturing and Construction as share of total tertiary degrees (ISCED 5A) in EU27 Member States in 2005 and 2010[1]

	2005			2010		
	Science, Math. and Computing	**Engin. Manuf. and Constr.**	***Total Science and Engin.***	**Science, Math. and Computing**	**Engin. Manuf. and Constr.**	***Total Science and Engin.***
EU27	10.1%	11.8%	*21.9%*	9.7%	12.2%	*21.8%*
BE	10.5%	10.7%	*21.2%*	6.2%	14.1%	*20.3%*
BG	5.2%	15.5%	*20.7%*	5.1%	15.6%	*20.7%*
CZ	8.0%	17.5%	*25.5%*	9.2%	14.7%	*23.9%*
DK	8.1%	9.5%	*17.6%*	8.5%	9.7%	*18.2%*
DE	14.1%	16.7%	*30.8%*	15.8%	13.2%	*29.0%*
EE	12.7%	10.6%	*23.4%*	11.5%	11.4%	*22.9%*
IE	15.9%	8.6%	*24.6%*	11.2%	9.5%	*20.7%*
GR	17.8%	9.9%	*27.6%*	14.7%	12.3%	*27.0%*
ES	9.4%	14.7%	*24.1%*	8.6%	14.6%	*23.2%*
FR	14.5%	12.0%	*26.4%*	12.6%	13.6%	*26.2%*
IT	6.4%	14.8%	*21.2%*	6.8%	14.5%	*21.3%*
CY	20.8%	0.0%	*20.8%*	10.1%	11.6%	*21.7%*
LV	5.2%	7.6%	*12.8%*	5.4%	8.9%	*14.3%*
LT	6.9%	15.1%	*22.0%*	6.3%	16.1%	*22.4%*
LU	n.a.	n.a.	*0.0%*	11.0%	6.3%	*17.3%*
HU	3.4%	6.7%	*10.1%*	6.6%	9.9%	*16.5%*
MT	4.8%	5.0%	*9.8%*	7.8%	5.7%	*13.5%*
NL	7.2%	8.1%	*15.3%*	5.8%	7.6%	*13.4%*
AT	12.8%	14.2%	*27.0%*	11.7%	14.3%	*26.0%*
PL	6.7%	7.4%	*14.1%*	6.9%	9.0%	*16.0%*
PT	6.7%	12.3%	*19.0%*	6.2%	18.5%	*24.7%*
RO	5.0%	17.2%	*22.2%*	4.7%	12.2%	*16.9%*
SI	5.9%	11.4%	*17.3%*	6.0%	13.0%	*19.0%*
SK	9.2%	17.6%	*26.8%*	7.7%	12.7%	*20.3%*
FI	8.2%	20.9%	*29.1%*	7.5%	24.1%	*31.6%*
SE	7.3%	18.3%	*25.5%*	6.7%	18.3%	*24.9%*
UK	14.1%	8.6%	*22.7%*	13.0%	9.5%	*22.5%*

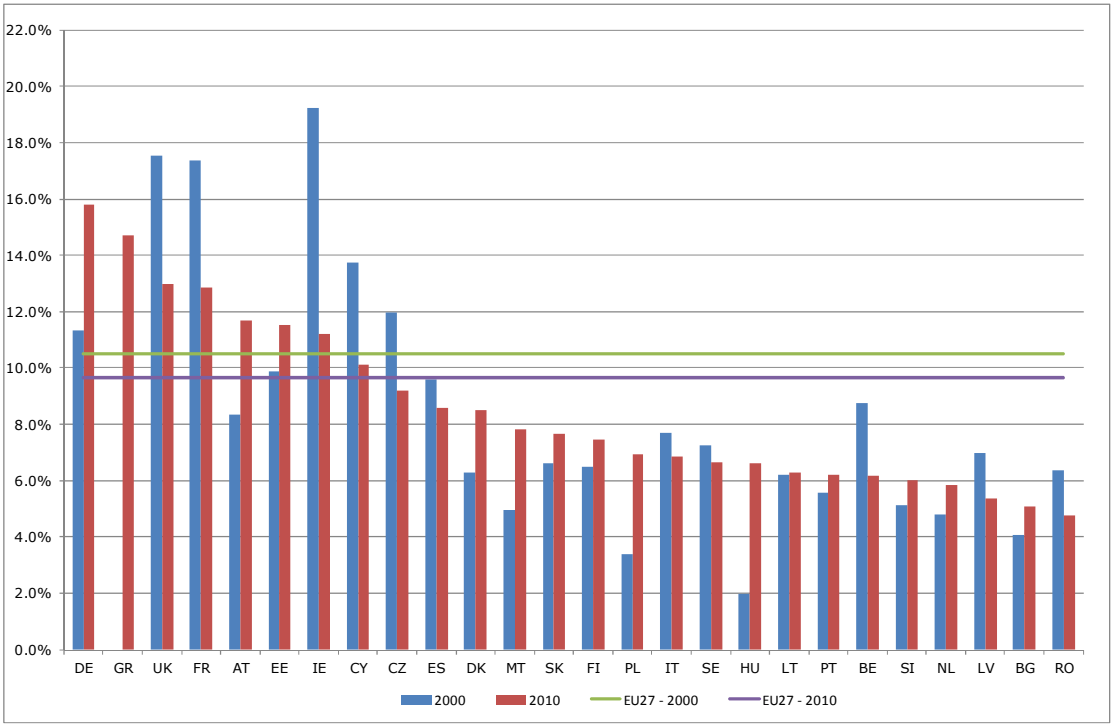
[1] 2010 data for Italy have been estimated (see note to Table 13).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 23: Share of Science and Engineering tertiary degrees in EU27, Japan and US, 2000-2010



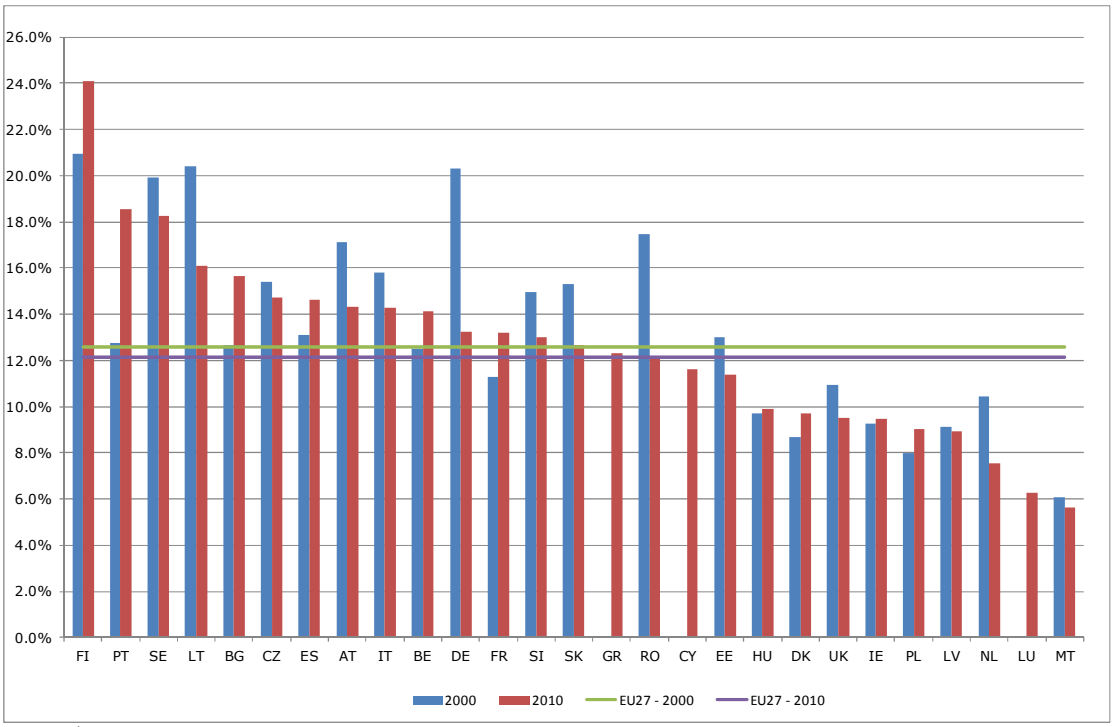
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 24: Share of Science, Mathematics and Computing tertiary degrees in EU27 Member States, 2000-2010[1]



[1] 2010 data for Italy have been estimated (see note to Table 13). Member States are ranked according to the 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 25: Share of Engineering, Manufacturing and Construction tertiary degrees in EU27 Member States, 2000-2010



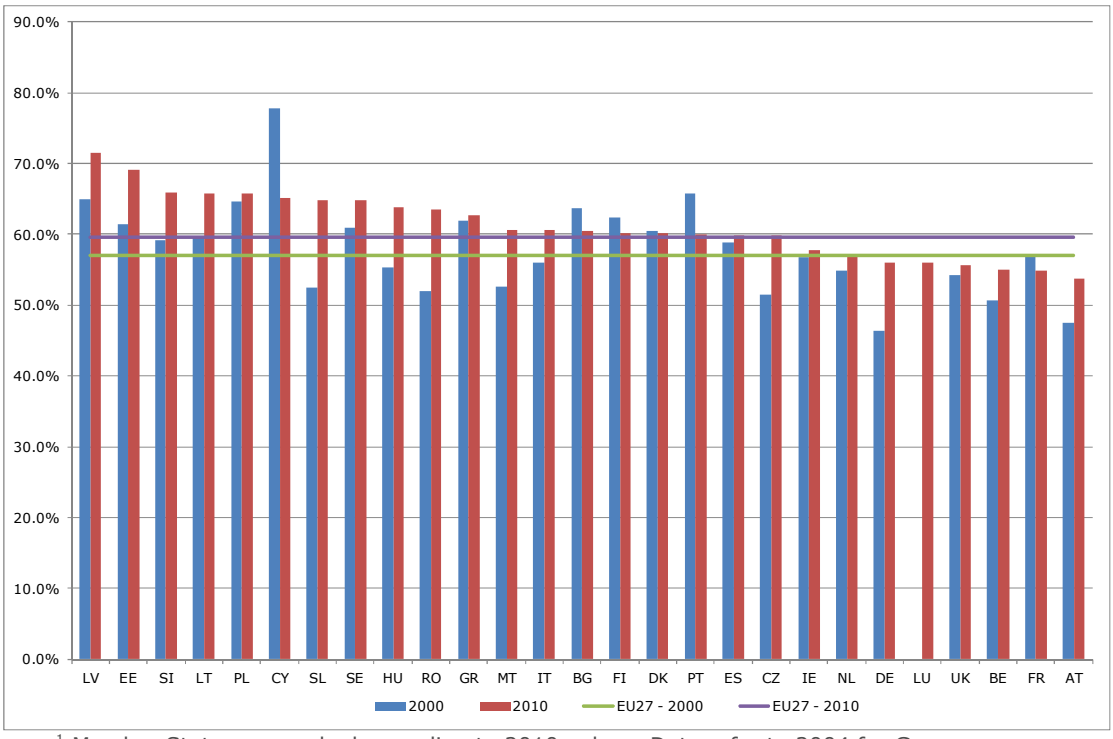
[1] 2010 data for Italy have been estimated (see note to Table 13). Member States are ranked according to the 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.1.2.3 Tertiary graduates (ISCAD 5A) by gender

The share of female first stage tertiary graduates (ISCED 5A) is largely higher than 50% in all the EU27 member States and has increased almost everywhere in the period 2000-2010 (Figure 26). The Baltic States and the Eastern European Member States have the highest share with a maximum value in Latvia (72%). Only eight Member States are characterized by a female tertiary graduates share below the 2010 EU27 average (amounting to 59%).

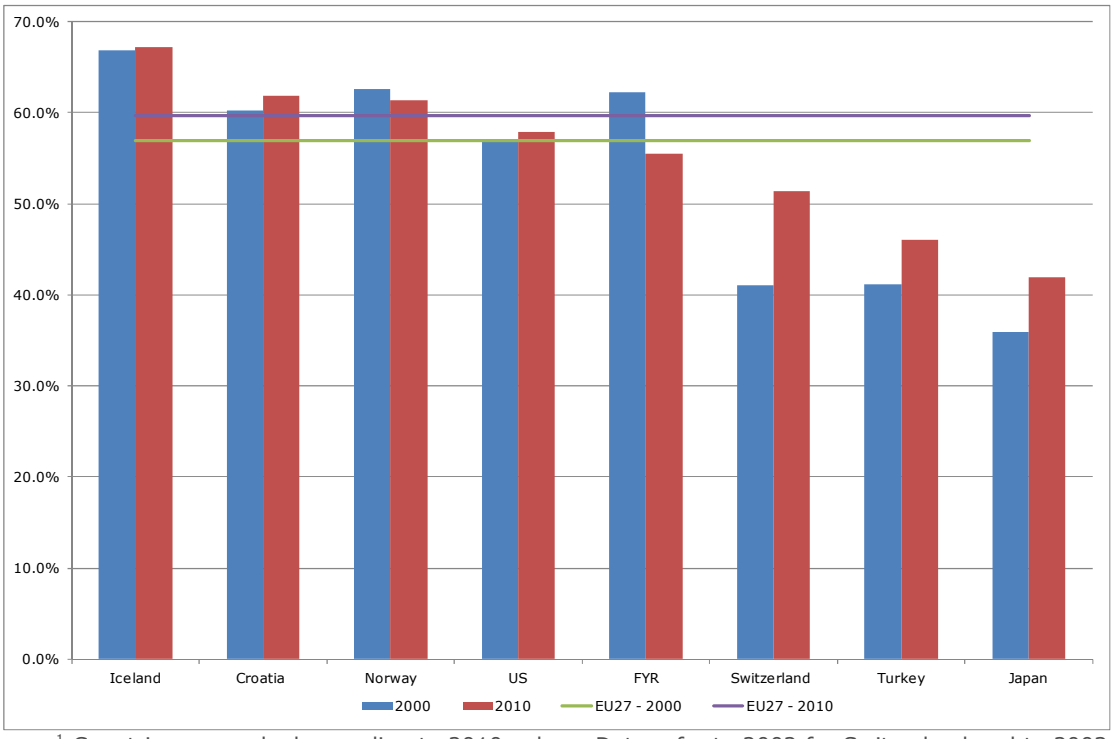
The situation among extra EU27 countries is more heterogeneous (Figure 27). Relatively high increases have been registered in Switzerland, Turkey and Japan, that are, however, still below the EU27 average. In the US, the increase has been smaller and in 2010 its share is still slightly below the EU27 value.

Figure 26: Share of female tertiary graduates (ISCED 5A) in EU27 Member States in 2000[1] and 2010[2]



[1] Member States are ranked according to 2010 values. Data refer to 2004 for Greece
[2] 2010 data for Italy have been estimated (see note to Table 13).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 27: Share of female tertiary graduates (ISCED 5A) in selected non-EU countries in 2000[1] and 2010

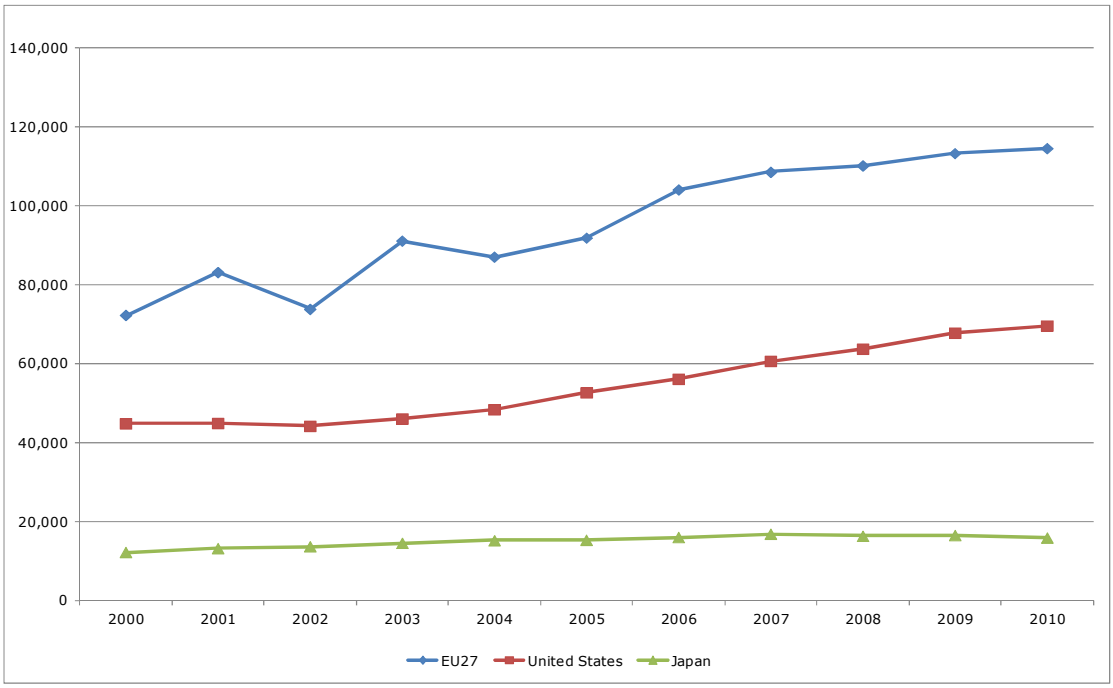


[1] Countries are ranked according to 2010 values. Data refer to 2002 for Switzerland and to 2003 for Croatia.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.2 Indicator 5: Total doctoral graduates

Figure 28 compares the EU27 with Japan and the US on the basis of the total number of doctoral degrees (i.e. the number of second level tertiary degrees, codified in ISCED 6) awarded between 2000 and 2010. EU values increase from 73,000 in 2002 to 115,000 in 2010. In that period the US experienced a constant increase: from 44,000 in 2002 to 64,000 in 2010. In Japan there was an upwards movement from around 12,000 to 16,000. However, the average annual increase in this country has been lower than in EU27 and US (2.7% against 4.3% and 4.5% respectively).

Figure 28: Number of doctoral graduates in EU27, Japan and US, 2000-2010



Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.2.1 Doctoral graduates by field of science

If we disaggregate the total number of doctoral degrees awarded in EU27 by Field of Science in the 2000-2010 period, as is done in Table 19, we find that the field with the highest number is Science, Mathematics and Computing, followed by Health and Welfare, Social Sciences, Business and Law. Engineering and Manufacturing ranks fourth. This ranking remained fairly stable over the whole period.

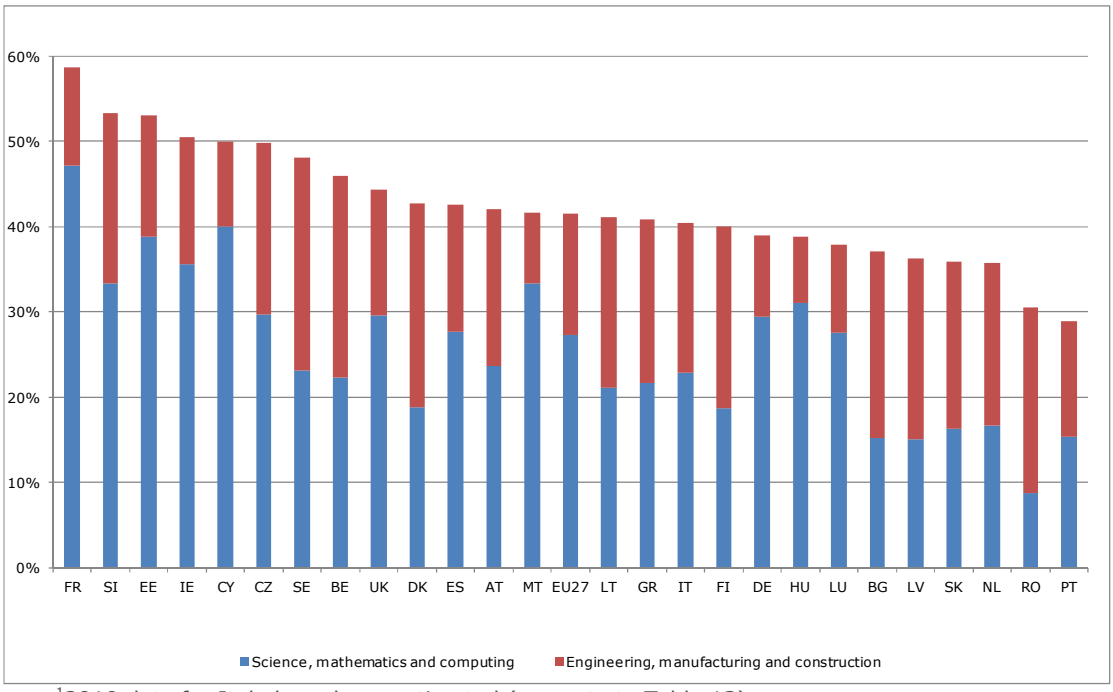
Concerning the shares of Science and Engineering doctoral graduates, France, Slovenia, Estonia and Ireland are the Member States at the top, all of them with shares well above 50% (Figure 29).

Table 19: Number of doctoral graduates by field of science in EU27 as share of total doctoral graduates, 2000, 2005 and 2010

	2000	2005	2010
Science, mathematics and computing	31.0%	27.1%	28.4%
Health and welfare	21.1%	21.3%	18.8%
Social sciences, business and law	16.5%	17.8%	18.5%
Engineering, manufacturing and construction	13.0%	13.4%	14.8%
Humanities and arts	11.6%	12.5%	12.0%
Teacher training and education science	2.5%	3.0%	3.0%
Agriculture and veterinary	3.7%	4.0%	3.3%
Services	0.7%	1.0%	1.2%
Total	***100.0%***	***100.0%***	***100.0%***

Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 29: Share of Science and Engineering doctoral graduates in EU27 Member States in 2010[1]



[1]2010 data for Italy have been estimated (see note to Table 13).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Table 20: Distribution of doctoral graduates in EU27 Member States by field of science in 2010[1]

	Teacher training and education science	Humanities and arts	Social sciences, business and law	Science, mathematics and computing	Engineering, manufacturing and construction	Agriculture and veterinary	Health and welfare	Services	Unknown or not specified	Total
BE	0.8%	9.7%	16.0%	22.4%	23.6%	5.2%	21.6%	0.6%	0.0%	100.0%
BG	5.4%	18.5%	22.1%	15.3%	21.8%	3.4%	9.1%	4.5%	0.0%	100.0%
CZ	4.2%	11.6%	13.9%	29.7%	20.2%	5.9%	9.0%	3.8%	1.8%	100.0%
DK	0.0%	11.3%	9.7%	18.8%	24.0%	5.3%	30.9%	0.0%	0.0%	100.0%
DE	3.1%	8.1%	16.0%	29.4%	9.7%	3.4%	29.6%	0.8%	0.0%	100.0%
EE	4.0%	12.0%	12.0%	38.9%	14.3%	3.4%	12.6%	2.9%	0.0%	100.0%
IE	3.5%	11.7%	10.8%	35.7%	14.9%	3.0%	15.5%	1.6%	3.3%	100.0%
GR	4.5%	11.2%	11.2%	21.7%	19.0%	8.4%	23.7%	0.0%	0.3%	100.0%
ES	2.2%	12.2%	18.9%	27.7%	14.9%	3.4%	12.5%	1.9%	6.4%	100.0%
FR	1.2%	15.2%	20.9%	47.1%	11.5%	0.1%	3.3%	0.7%	0.0%	100.0%
IT	1.7%	12.6%	17.7%	22.9%	17.6%	5.8%	14.3%	0.2%	7.1%	100.0%
CY	26.7%	3.3%	20.0%	40.0%	10.0%	0.0%	0.0%	0.0%	0.0%	100.0%
LV	6.8%	9.1%	26.5%	15.2%	21.2%	7.6%	12.1%	1.5%	0.0%	100.0%
LT	0.0%	12.6%	28.8%	21.2%	20.0%	3.9%	13.5%	0.0%	0.0%	100.0%
LU	8.6%	19.0%	27.6%	27.6%	10.3%	0.0%	6.9%	0.0%	0.0%	100.0%
HU	4.2%	21.3%	14.0%	31.1%	7.8%	6.6%	15.1%	0.0%	0.0%	100.0%
MT	0.0%	33.3%	16.7%	33.3%	8.3%	0.0%	8.3%	0.0%	0.0%	100.0%
NL	0.0%	7.6%	19.3%	16.8%	19.0%	6.3%	31.1%	0.0%	0.0%	100.0%
AT	2.8%	13.4%	28.1%	23.7%	18.4%	3.8%	7.6%	0.6%	1.5%	100.0%
PL	0.0%	25.8%	13.3%	16.7%	17.0%	5.8%	19.5%	1.9%	0.0%	100.0%
PT	5.9%	11.0%	18.9%	25.2%	19.9%	2.4%	11.0%	5.7%	0.0%	100.0%
RO	0.0%	22.4%	19.9%	8.8%	21.7%	12.3%	12.9%	2.1%	0.0%	100.0%
SI	2.4%	13.3%	16.3%	33.3%	20.0%	3.7%	6.9%	4.1%	0.0%	100.0%
SK	6.8%	12.8%	20.4%	16.3%	19.6%	4.6%	14.5%	5.1%	0.0%	100.0%
FI	5.3%	11.5%	16.7%	19.0%	21.3%	2.5%	21.4%	2.2%	0.0%	100.0%
SE	2.8%	6.7%	11.7%	20.9%	18.8%	2.0%	36.9%	0.1%	0.0%	100.0%
UK	3.9%	13.2%	20.3%	29.5%	14.8%	1.1%	17.1%	0.2%	0.0%	100.0%
EU27	***2.6%***	***12.6%***	***17.9%***	***27.4%***	***15.0%***	***3.7%***	***18.5%***	***1.0%***	***1.3%***	***100.0%***

[1]2010 data for Italy have been estimated (see note to Table 13).
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Table 21: Distribution of doctoral graduates in selected non-EU27 countries by field of science in 2010

	Teacher training and education science	Humanities and arts	Social sciences, business and law	Science, mathematics and computing	Engineering, manufacturing and construction	Agriculture and veterinary	Health and welfare	Services	Total
NO	0.1%	8.6%	9.8%	38.7%	0.5%	1.3%	39.9%	1.1%	100.0%
CH	1.1%	7.7%	18.7%	27.1%	11.6%	4.5%	26.4%	3.1%	100.0%
HR	1.7%	16.3%	17.1%	22.6%	16.0%	6.0%	19.3%	1.1%	100.0%
FYR	10.8%	24.2%	35.7%	7.6%	7.0%	0.0%	8.3%	6.4%	100.0%
TR	11.2%	12.8%	21.5%	18.2%	14.8%	8.2%	12.4%	1.1%	100.0%
US	13.3%	11.1%	18.4%	22.9%	11.5%	1.3%	20.3%	1.4%	100.0%
JP	2.4%	10.1%	10.5%	15.9%	23.0%	6.9%	30.6%	0.5%	100.0%

Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

The proportion of degrees awarded in the various fields was not uniform across the EU27 Member States in 2010 (Table 20). The more variable fields are Teacher Training, Education, Science and Health and Welfare. Likewise, heterogeneity also emerges in non-EU countries (

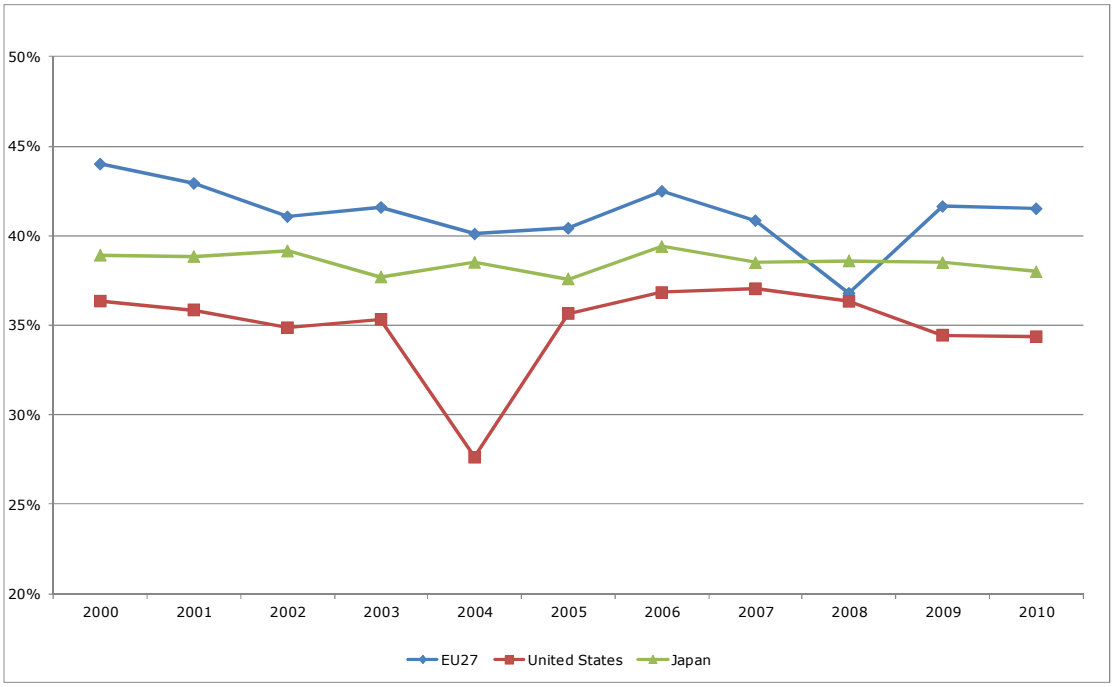
Table 21).

Figure 30 reports the share of Science and Engineering doctoral degrees in the total number of doctoral degrees in the period 2000-2010. The EU27 has highest share in each year except in 2008, when Japan was first. In general, the data show no significant changes over the period.

The share of doctoral degrees in Science and Engineering in the EU27 has remained around 42% in 2000-2010, with the share of degrees in Science, Mathematics and Engineering being higher than that of Engineering, Manufacturing and Construction (Figure 31).

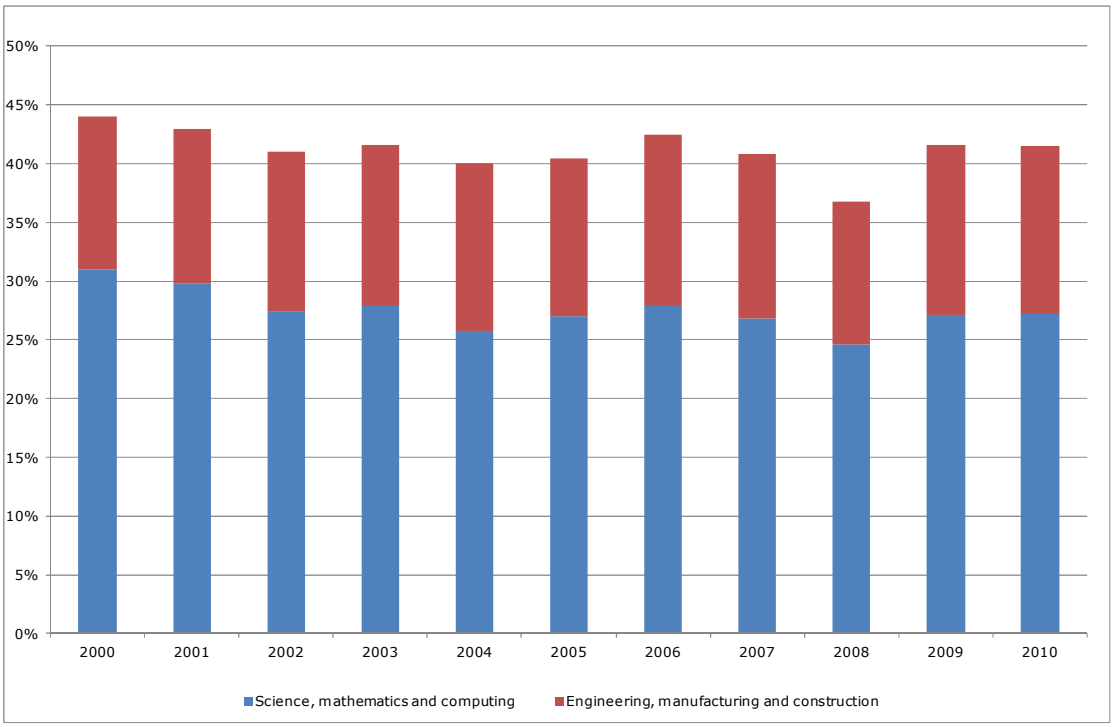
The share of degrees in Science, Mathematics and Engineering was higher than Engineering, Manufacturing and Construction also in US (Figure 32); on the contrary it was considerably lower in Japan (Figure 33).

Figure 30: Share of Science and Engineering degrees on total number of doctoral degrees in EU27, Japan and US, 2000-2010



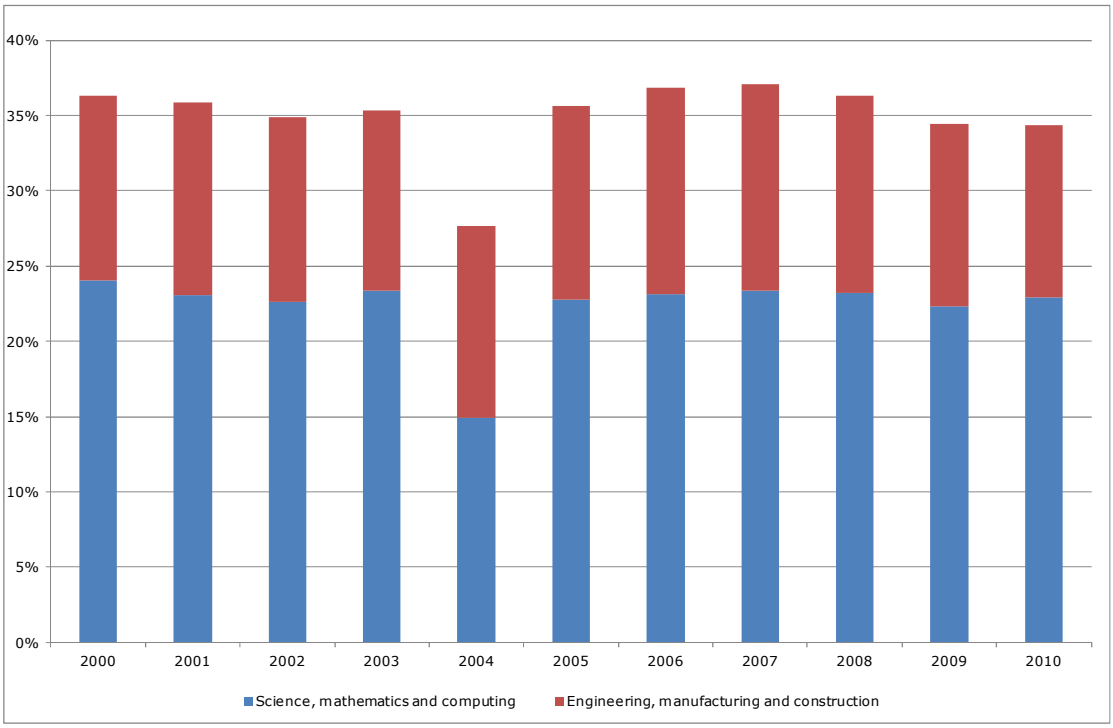
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 31: Share of Science and Engineering doctoral graduates in EU27, 2000-2010



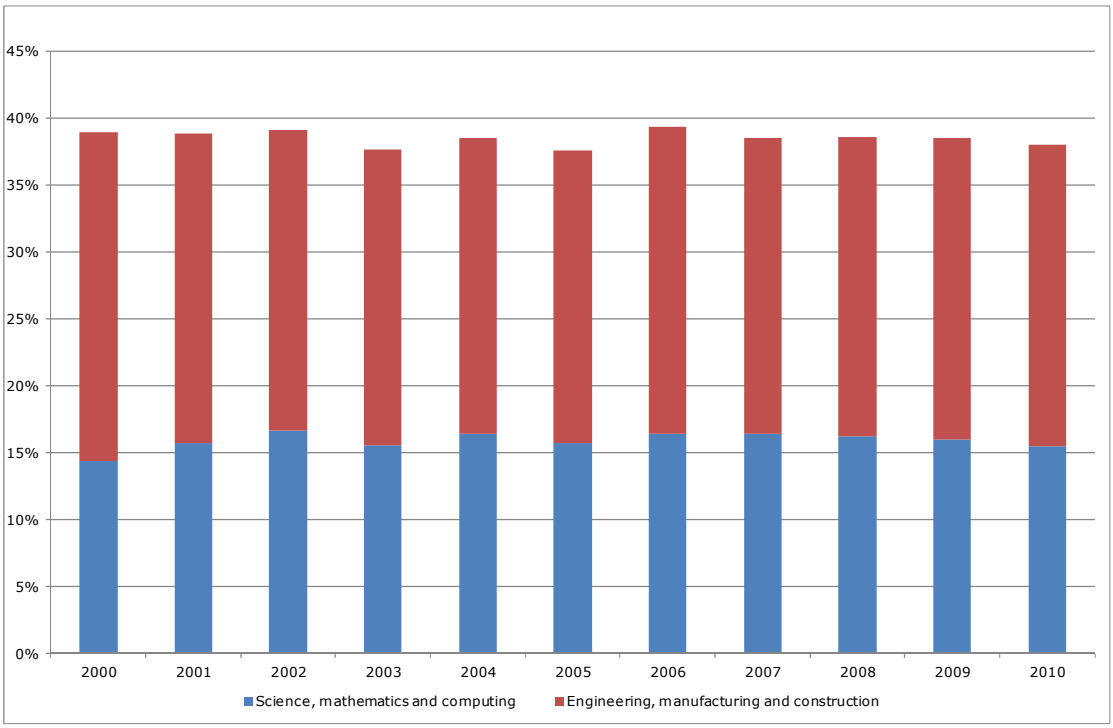
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 32: Share of Science and Engineering doctoral graduates in US, 2000-2010



Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 33: Share of Science and Engineering doctoral graduates in Japan, 2000-2010



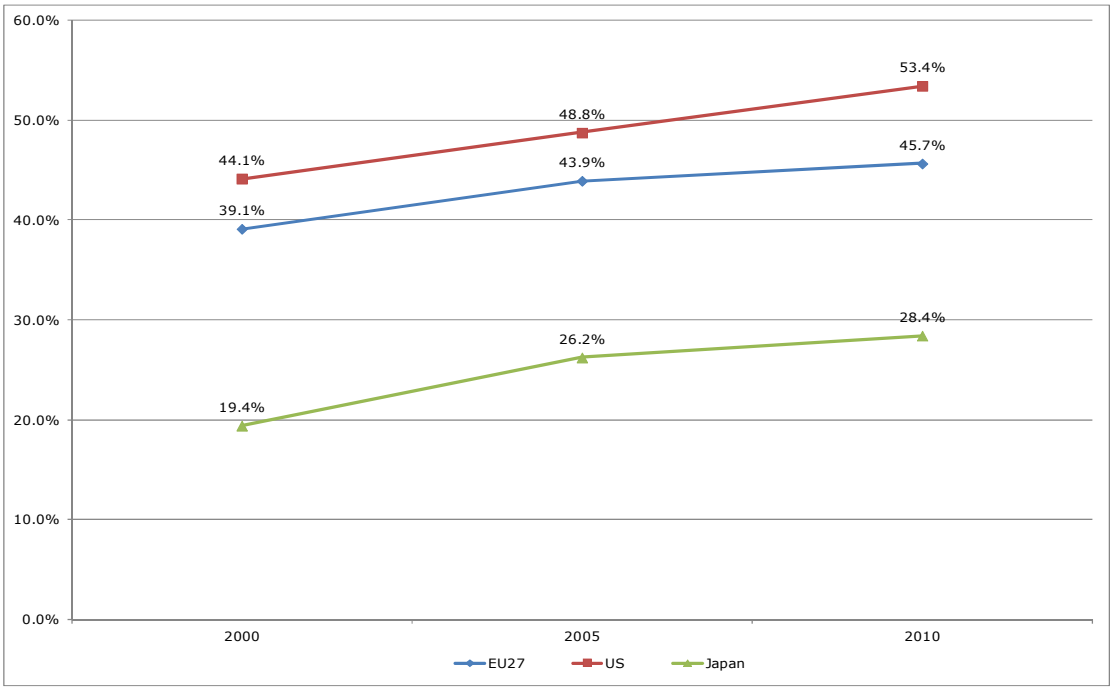
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.2.2 Doctoral graduates by gender

The US is the only country, of the three we are comparing, where the number of female students obtaining a doctorate is larger in number than males (however in some Member States the female share is higher than in the US; Figure 35), even if the gender gap also reduced in the EU27 and Japan. In the EU27 as a whole, male doctoral graduates outnumber females by 8.6 p.p. while in Japan the number of doctoral degrees awarded to men is 2.5 times that awarded to women (Figure 34).

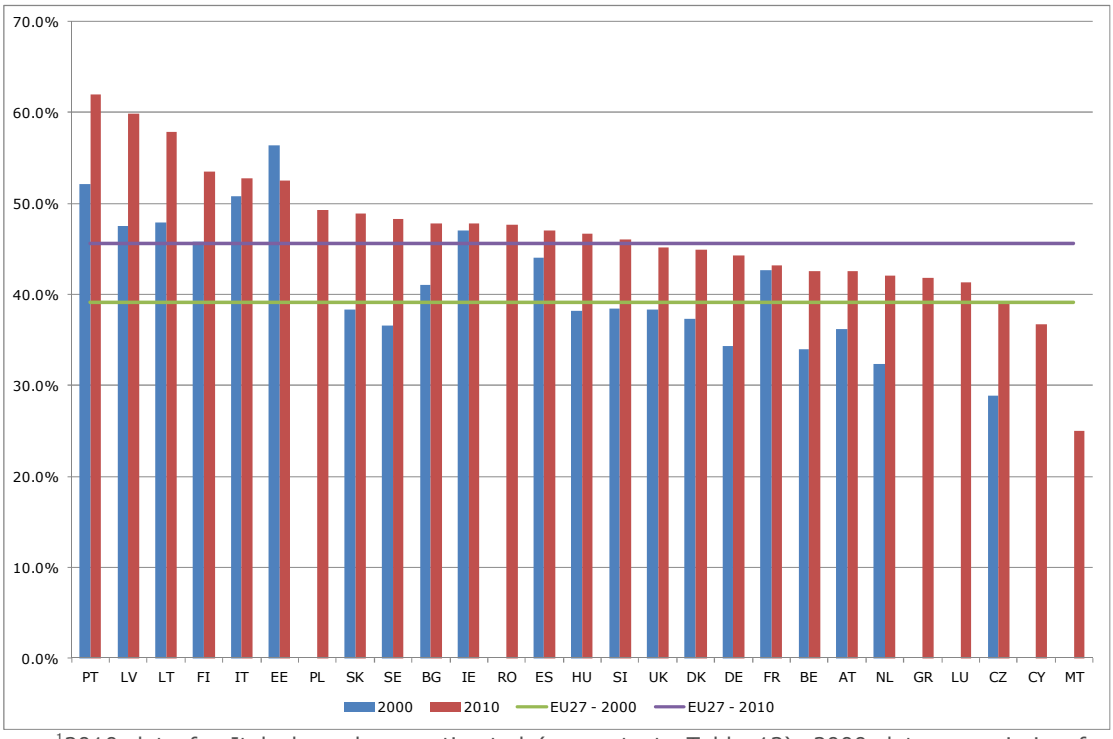
Figure 35 shows that within EU 27 the values are rather dispersed: Sweden, Finland, Portugal, Poland, Italy and the three Baltic countries are above the 50% threshold, while many others are at around 40%. The EU27 average is 45%. Croatia and the FYR have values above 50%, not too far from US and much higher than Japan (Figure 36).

Figure 34: Share of females doctoral graduates in EU27, US and Japan in 2000, 2005 and 2010



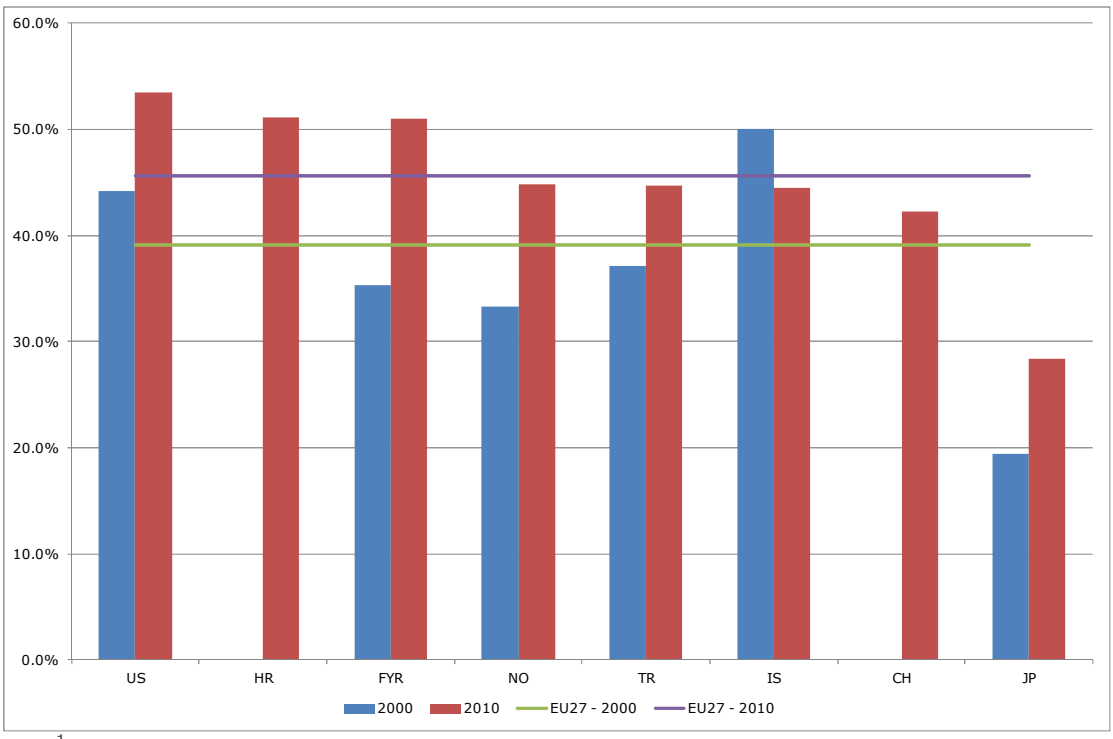
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 35: Share of female doctoral graduates in EU27 Member States in 2000 and 2010[1]



[1]2010 data for Italy have been estimated (see note to Table 13). 2000 data are missing for Greece, Luxembourg, Cyprus and Malta. Member States are ranked according to the 2010 value.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

Figure 36: Share of females doctoral graduates in selected non-EU countries in 2000 and 2010[1]

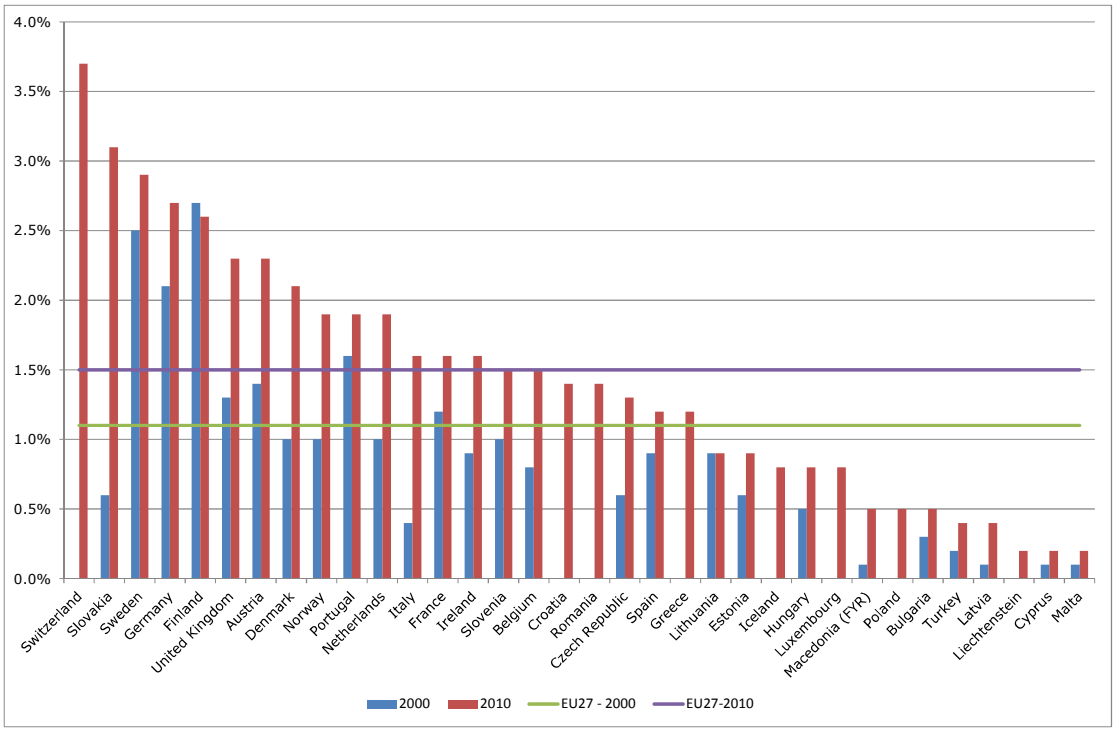


[1]2000 data are missed for Croatia and Switzerland. Countries are ranked according to the 2010 value.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en

5.2.3 Doctoral graduates by age

In Figure 37, the number of new doctoral graduates per thousand aged 25-34 in 2000 and 2010 is displayed for each EU27 Member State, the EEA and the Candidate countries. In 2010 the countries with the highest values – over 2.5% – are Switzerland, Slovakia, Sweden, Germany and Finland, while among EU27 Member States, Poland, Bulgaria, Latvia, Cyprus and Malta show very limited values (below 0.5%).

Figure 37: New doctoral graduates (ISCED 6) per thousand population aged 25-34, Europe, 2000 and 2010 in EU27 Member States and selected non-EU countries[1]



[1] Researchers Report/IUS
Source: Own calculations based on EUROSTAT data from the following website:
http://appsso.eurostat.ec.europa.eu/nui/show.do?wai=true&dataset=educ_itertc

6 MOBILITY OF DOCTORAL CANDIDATES

In the following section we will first provide information about mobility within the EU27 Member States by tertiary graduated EU citizens and those enrolled in post-tertiary courses in EU27 Member States. We distinguish between EU doctoral candidates by Member State of origin (Indicator 6) and by destination (Indicator 7). Subsequently we will focus on mobility outside the EU and from non-EU countries, providing information about non-EU doctoral candidates studying in EU Member States (Indicator 8) and about tertiary graduated EU citizens studying in non-EU countries (Indicator 9).

We will then analyse researchers' mobility during the post-doctoral career stages (Indicator 10), also distinguishing them on the basis of the length of their stay abroad (Indicators 11 and 12). Finally, information about employer mobility (Indicators 13), inter-sectorial mobility (Indicator 14) and non-mobility (Indicator 15) will be reviewed briefly.

The total number of EU27 doctoral candidates in 2010 was about 735,000[37]. The EU27 share of doctoral candidates studying in an EU country which is not their country of citizenship is approximately 7.8% (Source: Eurostat). About 20% of the EU27 doctoral candidates studying in an EU country originate from a third country (Source: Innovation Union Scoreboard, Eurostat).

[37] No data is available on the number of doctoral candidates for Germany in 2010. Germany estimates its number of doctoral candidates at 200,400 for 2011. This number was integrated in the 2010 total.

6.1 Indicator 6: Mobility of EU doctoral candidates (ISCED 6) within Europe, by country of origin

The total number of doctoral candidates in EU27 in 2010 was about 735,000[38]. Of the 535,000 for which a breakdown by citizenship is available, 41,600 are European nationals studying in an EU27 Member State other than their home country. This represents a 25% increase on the number in 2005: 33,317 'foreign' European researchers.

Table 22: Number of doctoral candidates studying in another EU Member State in 2005 and 2010, by citizenship[1]

Country	2005	2010	% Growth 2010/2005
DE	3,921	7,575	93.2%
IT	3,631	5,588	53.9%
GR	3,959	3,022	-23.7%
PT	2,411	2,541	5.4%
PL	1,083	2,278	110.3%
FR	1,823	2,040	11.9%
RO	1,053	1,696	61.1%
SK	2,039	1,685	-17.4%
ES	1,416	1,421	0.4%
IE	1,238	1,306	5.5%
NL	590	899	52.4%
CY	428	703	64.3%
UK	362	701	93.6%
SE	400	611	52.8%
BG	674	584	-13.4%
CZ	306	580	89.5%
HU	405	561	38.5%
BE	554	517	-6.7%
AT	292	470	61.0%
FI	381	364	-4.5%
DK	356	284	-20.2%
LT	246	257	4.5%
MT	136	247	81.6%
EE	218	230	5.5%
LU	247	191	-22.7%
SI	143	175	22.4%
LV	77	128	66.2%

[1] For a given nationality, the number of doctoral candidates abroad is calculated by summing up the numbers provided for this nationality by the receiving EU countries. For example, 5,588 doctoral candidates with Italian citizenship were in a Member State other than Italy in 2010. Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

The number and evolution of doctoral candidates for each of the EU27 nationalities studying in the other Member States are reported in Table 22. These data offer an indication of the intra-EU flows of doctoral candidates per EU27 nationality. Germany, Italy and Greece are at top of the list (in absolute terms) of the Member States whose doctoral candidates study in other Member States (Table 22).

As concerns the number of national doctoral candidates studying in another Member State as a share of total doctoral candidates studying or working in the

[38] The total includes an estimate of the 200,400 doctoral candidates in Germany. However, for the reason given in the note to **Error! Reference source not found.**, we cannot take account of the German data in the disaggregation by nationality of the EU doctoral candidates studying in another Member State.

country of origin (Table 23), the smaller EU countries like Malta, Cyprus and Luxembourg, present the highest share followed by Slovakia, Ireland, Bulgaria, Portugal, and Italy (all with a share of approx. 15%). On the contrary, the UK is characterized by the lowest share of doctoral candidates with UK citizenship studying or working in other EU Member States.

Table 23: Number of national doctoral candidates studying in another Member State[1] as a share of total doctoral candidates in the country of origin in 2005 and 2010

Country	2005	2010	% Growth 2010/2005
MT	256.6%	358.0%	39.5%
CY	170.5%	144.4%	-15.3%
LU	n.a.	53.4%	n.a.
SK	19.8%	15.4%	-22.3%
IE	25.7%	15.3%	-40.2%
BG	13.3%	15.2%	14.3%
PT	13.1%	15.1%	15.0%
IT	9.7%	14.6%	51.1%
GR	17.7%	13.3%	-25.0%
NL	7.9%	11.2%	41.0%
LT	8.7%	8.8%	0.8%
EE	12.1%	8.7%	-28.4%
HU	5.1%	8.2%	61.4%
PL	3.3%	6.4%	94.8%
LV	5.4%	5.9%	10.3%
RO	4.7%	5.9%	24.3%
SI	14.8%	5.1%	-65.4%
BE	7.5%	3.9%	-48.6%
DK	8.1%	3.6%	-55.4%
SE	1.8%	3.1%	69.8%
FR	2.2%	2.9%	29.7%
CZ	1.2%	2.2%	82.1%
ES	1.9%	2.0%	8.7%
FI	1.8%	1.8%	0.6%
AT	1.8%	1.8%	-5.0%
UK	0.4%	0.8%	108.3%
DE	n.a.	n.a.	n.a.

[1] Germany does not provide the total number of doctoral candidates (ISCED 6) disaggregated with respect to ISCED 5 students, therefore the data for Germany are missing.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

6.2 Indicator 7: Mobility of EU doctoral candidates (ISCED 6) within Europe, by country of destination

Table 24 presents the absolute number of European doctoral candidates in each of the EU27 host Member States. The Member State with the highest number of other European doctoral candidates in 2010 is the UK (13,937), followed by France (5,734), Austria (4,880) and Spain (3,997).

On the contrary, Lithuania (10), Latvia (18) and Cyprus (38) are the Member States with the lowest number of European doctoral candidates coming.

Table 24: Number of doctoral candidates with the citizenship of another EU27 Member State in the hosting Member State in 2005 and 2010[1]

	2005	2010	% Growth 2010/2005
EU27	33,317	41,600	24.9%
UK	12,189	13,937	14.3%
FR	6,441	5,734	-11.0%
AT	2,400	4,880	103.3%
ES	3,334	3,997	19.9%
CZ	1,198	2,174	81.5%
SE	2,019	2,006	-0.6%
BE	966	1,819	88.3%
IE	n.a.	1,366	n.a.
FI	980	1,188	21.2%
IT	807	n.a.	n.a.
DK	363	971	167.5%
SK	37	694	1775.7%
PL	841	632	-24.9%
PT	289	510	76.5%
RO	603	501	-16.9%
HU	548	389	-29.0%
LU	n.a.	243	n.a.
Sl	44	228	418.2%
EE	35	138	294.3%
BG	193	127	-34.2%
CY	25	38	52.0%
LV	n.a.	18	n.a.
LT	4	10	150.0%
MT	1	n.a.	n.a.
GR	n.a.	n.a.	n.a.
NL	n.a.	n.a.	n.a.
DE	n.a.	n.a.	n.a.

[1] Data for Germany, Greece and Netherlands are not available. Member States are ranked according to the 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

Table 25 shows the number of doctoral candidates in each Member State with European citizenship in 2010 as a share of total doctorate candidates studying in the country. Apart from Luxembourg, whose large share is mainly due to its small size, the UK is characterized by the highest share (16.0%) and by positive growth in the period 2005-2010.

Luxembourg (67.9%), Austria (18.2%), UK (16.4%), Ireland (16%), Belgium (13.6%), Denmark (12.4%) and Sweden (10%) are the countries with a share higher than the EU27 average in 2010.

Table 25: Ratio between the number of doctoral candidates with the citizenship of another EU27 Member State and the total doctoral candidates studying in that Member State[1] in 2005 and 2010

	2005	2010	% Growth 2010/2005
EU27	6.4%	7.8%	22.4%
LU	n.a.	67.9%	n.a.
AT	15.2%	18.2%	20.0%
UK	13.3%	16.4%	23.0%
IE	n.a.	16.0%	n.a.
BE	13.1%	13.6%	3.8%
DK	8.3%	12.4%	49.4%
SE	9.1%	10.0%	10.4%
CZ	4.8%	8.4%	74.4%
FR	7.8%	8.0%	3.2%
CY	10.0%	7.8%	-21.7%
Sl	4.6%	6.7%	46.5%
SK	0.4%	6.3%	1662.8%
FI	4.5%	5.8%	27.6%
HU	6.9%	5.7%	-17.3%
ES	4.4%	5.7%	29.8%
EE	1.9%	5.2%	167.5%
BG	3.8%	3.3%	-13.2%
PT	1.6%	3.0%	92.5%
PL	2.5%	1.8%	-30.4%
RO	2.7%	1.7%	-35.9%
LV	n.a.	0.8%	n.a.
LT	0.1%	0.3%	141.2%
IT	2.2%	n.a.	n.a.
MT	1.9%	n.a.	n.a.
GR	n.a.	n.a.	n.a.
NL	n.a.	n.a.	n.a.
DE	n.a.	n.a.	n.a.

[1] Germany, the Netherlands and Greece have missing because they do not supply data distinguishing ISCED 5 and ISCED 6 students.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

The EU27 share of doctoral candidates studying in an EU Member State other than that of her/his citizenship is 7.8%. When analysing the net movement of students within the EU27 Member States, Figure 38 shows which countries have a net inflow or outflow of doctoral candidates.

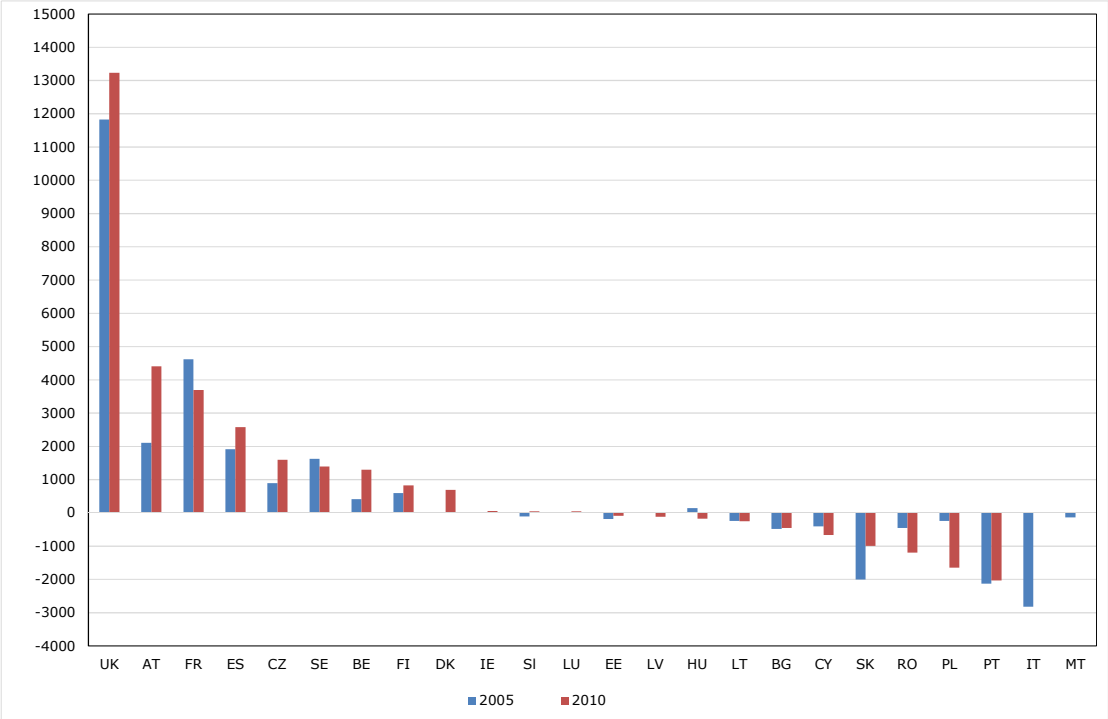
The UK is characterized by the highest net inflow, with a positive gap of around 13,000. Austria, France and Spain follow with a net inflow of 4,410, 3,694 and 2,576 doctoral candidates, respectively.

On the contrary, Italy is characterized by the highest net outflows of national doctoral candidates within the EU27 (2,824 in 2005) followed by Portugal, Poland, Romania and Slovakia.

One of the reasons behind these results could be the advantage provided by the language: English, French and Spanish are the most widely known and spoken languages in the EU. Another important issue to note is that the German data is not available.

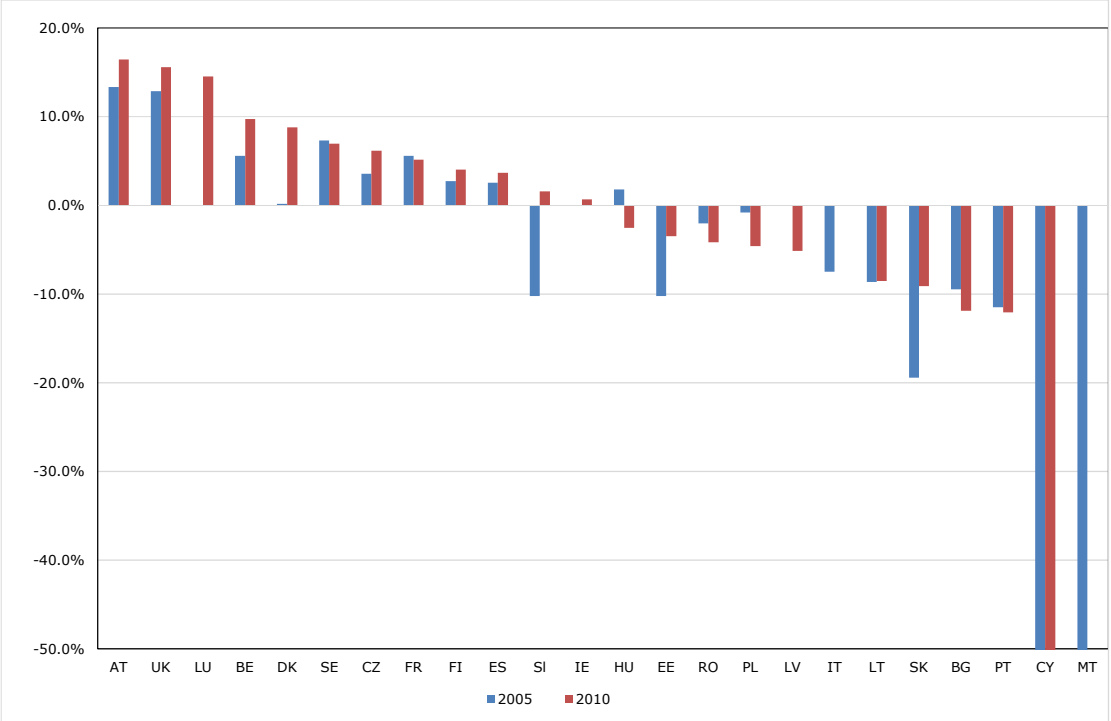
In Figure 39 inflows and outflows are reported as a share of doctoral candidates enrolled in the Member State. The picture differs slightly from the previous one: Cyprus, Portugal and Bulgaria have the highest negative balance and Austria and the UK have the similar positive balance (16%).

Figure 38: Intra EU "net gain" of doctoral candidates: differences between the number of doctoral candidates coming from other EU27 Member States and the number of doctoral candidates studying abroad for each Member State[1] in 2005 and 2010



[1] Data for Germany, the Netherlands and Greece not available. Member States are ranked according to the 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

Figure 39: Share of intra EU "net gain" of doctoral candidates expressed as share of doctoral candidates enrolled in that Member State[1] in 2005 and 2010[2]



[1] Data for Germany, Greece and the Netherlands is not available. Member States are ranked according to the 2010 values.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

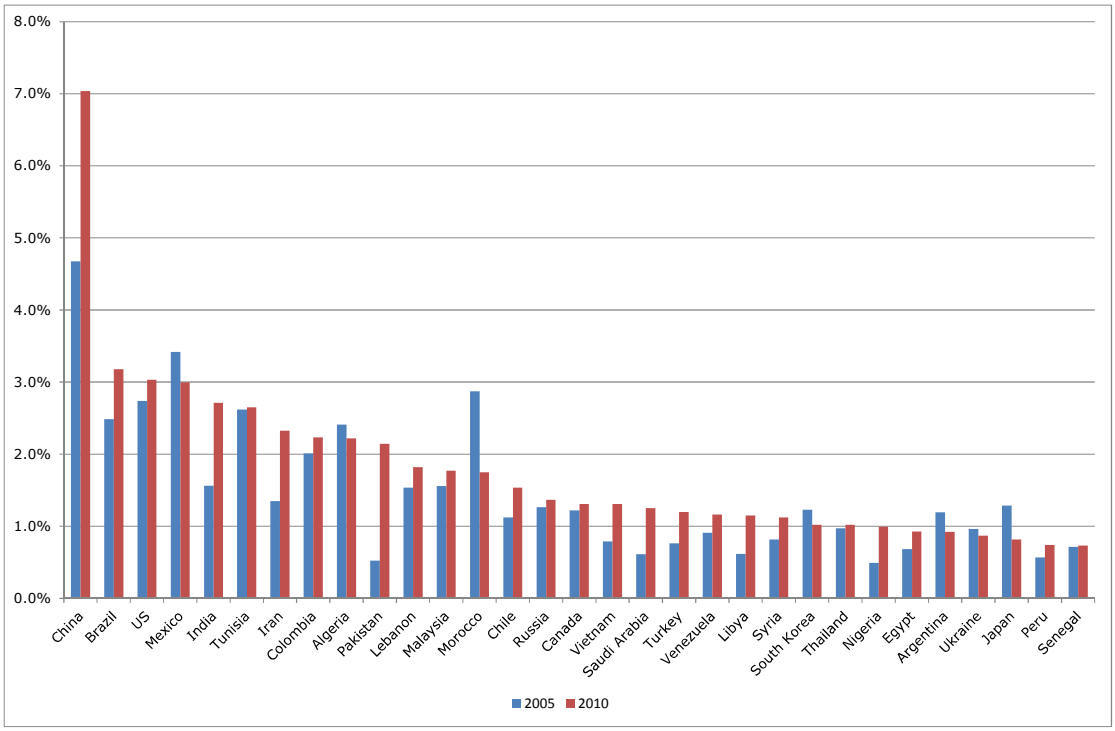
6.3 Indicator 8: Inflows of doctoral candidates into EU27[39]

About 20% of the doctoral candidates in EU27 come from third countries. Figure 40 shows the citizenship of doctoral candidates enrolled in the EU27 as a share of total foreign doctoral candidates in EU27. Among the extra-EU tertiary graduates attending ISCED 6 programmes in one of the Member States, the Chinese come first with almost 7,500 individuals (around 7% of the total inflow), followed by Brazilians (3,400, around 3% of the total inflow). Furthermore, it has to be pointed out that the shares of those coming from China and India increased substantially in the period 2005-2010.

Figure 41 and Table 26 show the distribution and evolution of non-EU doctoral candidates in EU Member States and Associated or Candidate Countries. The highest share of non-EU doctoral candidates in 2010 is found in Switzerland (48%). France, United Kingdom, Norway, Ireland, Iceland and Luxembourg are also above EU average. Since 2006, there has been a substantial growth in this share in the EU from 17% to 20%. This upward trend is also noticeable in many of the individual countries including those with high shares (for example France, Norway, Iceland, Sweden, Denmark and Portugal).

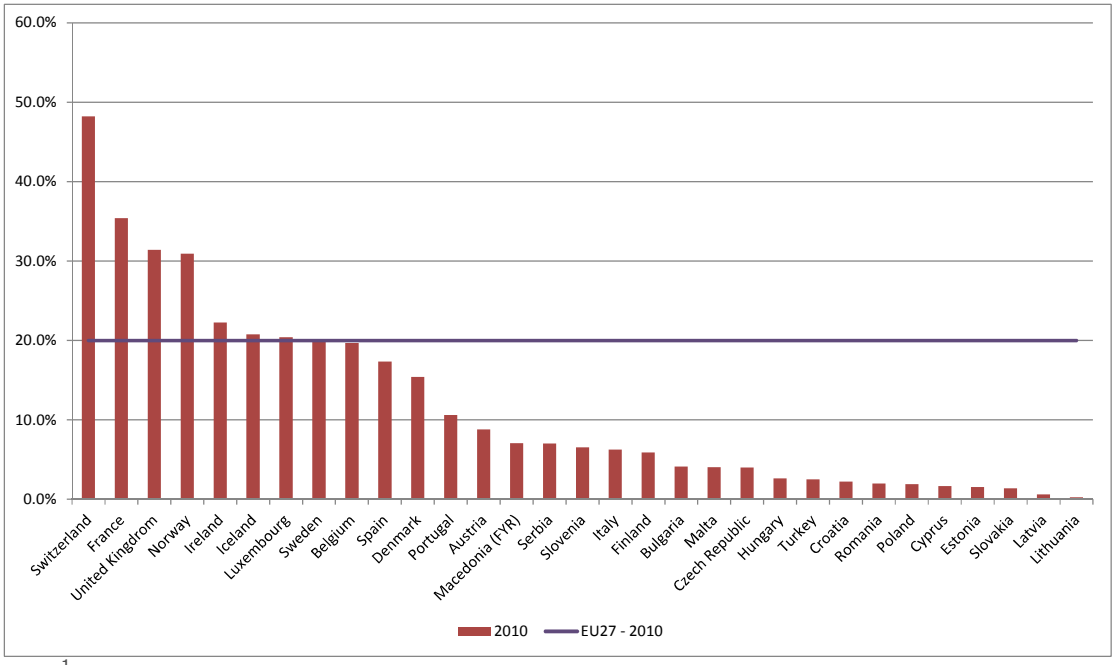
[39] Section 6.3 thus provides an overview of the inflows of doctoral candidates in EU27. For overview on the (estimates) of non-EU researchers currently working in EU27, see Annex 3.

Figure 40: Number of doctoral candidates coming from non-EU27 countries in 2005 and 2010 as a share of total foreign doctoral student in EU27, by country of origin



Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

Figure 41: Non-EU doctoral candidates as a percentage of all doctoral candidates, 2010[1]



[1] Data for Germany, Greece and the Netherlands are not available.
Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

Table 26: Share of non-EU doctorate candidates by country (%)

	2006	2007	2008	2009	2010
Switzerland	44.2	45	45.9	47	48.2
France	29.2	31.2	33.1	34.3	35.4
UK	28.5	30.6	31.1	31.6	31.4
Norway	22.3	23.4	25.0	29.1	30.9
Ireland	22.3	22.3	22.3	22.3	22.3
Iceland	12.2	14.4	17.4	23.0	20.8
Luxembourg	20.4	20.4	20.4	20.4	20.4
Sweden	13.9	14.7	16.2	18.3	20.0
Belgium	19.8	18.2	19.0	19.3	19.7
Spain	14.9	16.8	19.0	17.1	17.3
Demark	12.1	14.1	8.9	10.5	15.4
Portugal	6.0	7.8	9.1	10.0	10.6
Austria	8.2	8.5	10.5	11.1	8.8
Serbia	8.5	8.5	8.5	4.1	7.1
Macedonia	3.4	3.4	3.4	1.3	7.0
Slovenia	4.2	4.6	5.8	6.6	6.5
Italy	3.4	4.1	5.0	6.2	6.2
Finland	4.0	4.2	4.5	5.1	5.9
Malta	1.6	2.8	4.5	4.1	4.1
Bulgaria	4.1	4.0	3.5	3.9	4.1
Czech Republic	3.0	3.1	3.7	3.7	4.0
Hungary	3.2	3.0	3.4	2.8	2.6
Turkey	2.7	2.6	2.7	2.8	2.5
Croatia	2.1	2.5	2.5	2.5	2.2
Romania	2.6	2.0	1.7	2.1	2.0
Poland	2.3	2.3	2.2	2.0	1.9
Cyprus	1.3	1.4	1.1	1.8	1.6
Estonia	1.2	1.8	2.4	3.0	1.5
Slovakia	0.5	0.7	1.3	1.4	1.4
Greece	1.0	1.0	1.0	1.0	1.0
Latvia	0.2	0.3	0.3	0.5	0.6
Lithuania	0.1	0.0	0.8	0.6	0.2
EU27	***17.0***	***18.4***	***19.9***	***20.5***	***20.0***

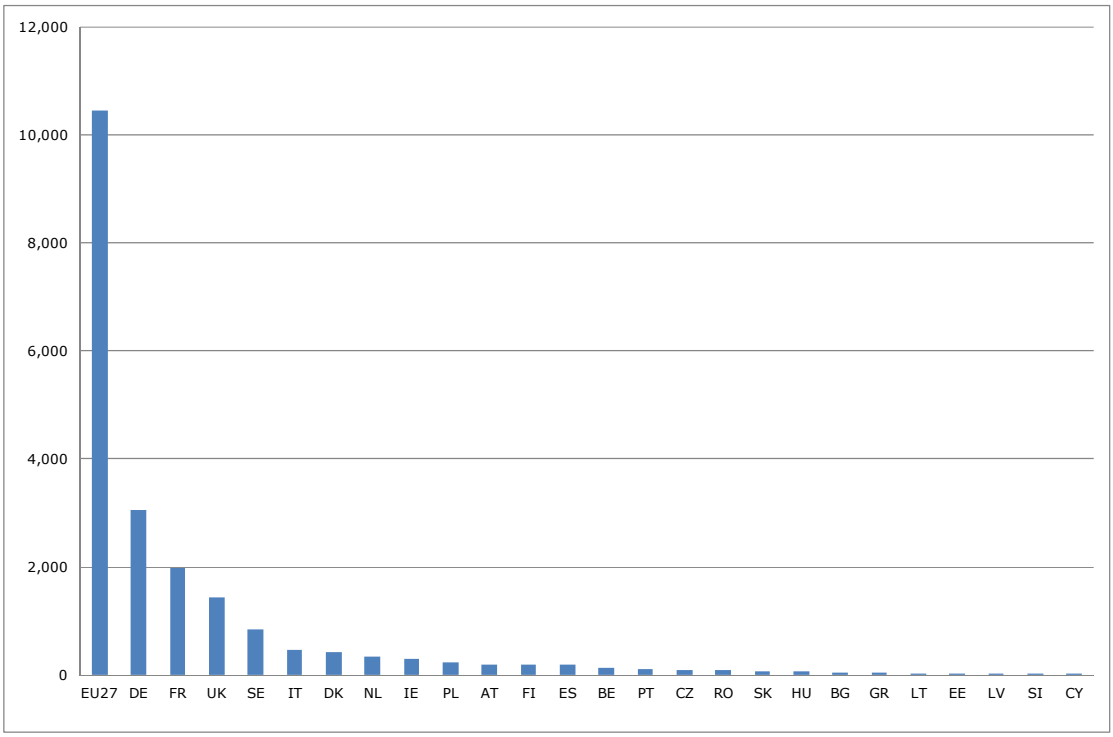
Source: DG Research and Innovation; Innovation Union Scoreboard 2013; based on EUROSTAT data

6.4 Indicator 9: Mobility of EU27 graduate students out of Europe

There are no complete and comparable data available to assess the mobility of EU27 graduate students and researchers moving out of Europe. We have partial data, usually referring to specific countries and/or covering a limited period of time. The country providing the most information is the US. Some limited information from Australia and Japan is also available. We will now review the existing data and in section 7.1 will attempt to make an estimate of EU-born researchers (identified both by their occupation and education) working in the US and in some other non-EU countries.

We start with the number of students[40] enrolled at Australian Universities in 2011 who are citizens of one of the Member States (Figure 42). The total number was slightly above 10,000. Most of them come from Germany (almost 1/3), France, UK and Sweden.

Figure 42: Number of EU27 students in Australia by Member State of origin in 2011

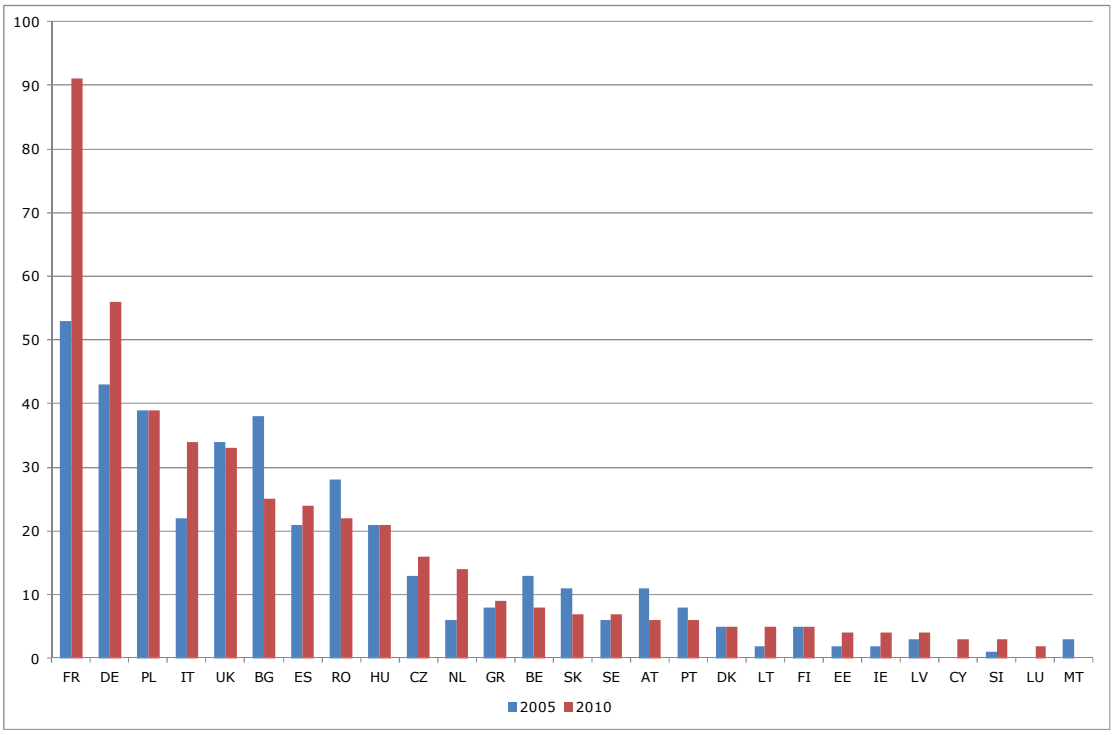


Source: Own calculations based on 'Students: Selected Higher Education Statistics'; Australian Government; Department of Industry, Innovation, Science, Research and Tertiary Education, 2012

The numbers of doctoral candidates coming from EU27 countries is also available for Japan, both for 2005 and 2010. The total number was 493 in 2010, up from 398 in 2005. As shown in Figure 43, most candidates come from France (and their increase between 2005 and 2010 has been very sharp, at least in terms of rate of growth).

[40] No distinction can be made between doctoral students and other students by country of citizenship. In Australia, there are about 145,000 foreign students enrolled in 2011. Of these 145,000 foreign students, there are about 4,200 doctoral candidates (2.9%). No breakdown by country of citizenship is possible here.

Figure 43: Number of EU27 doctoral candidates studying in Japan, 2005 and 2010

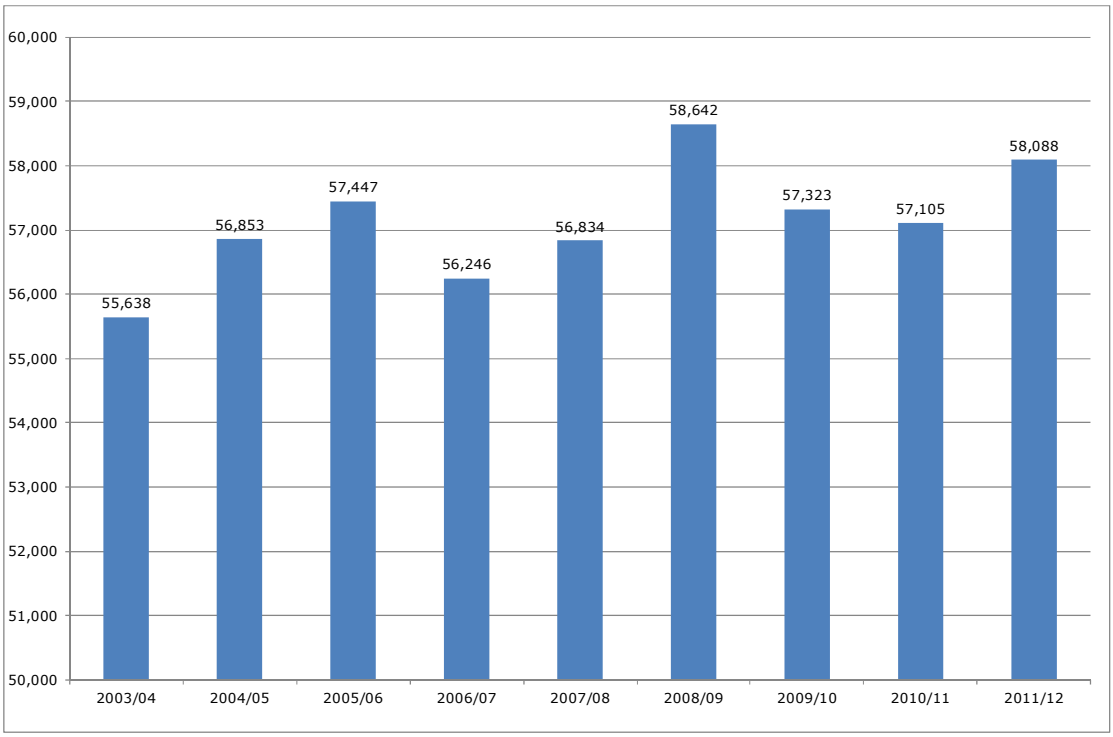


Source: Own calculations based on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en

We now focus on the US, where several datasets on EU born graduate students and researchers are collected. We start with the number of EU27 born students enrolled in graduate and professional programmes for the period 2003-2011

As shown in (Figure 44), from 2003-2004 to 2011-2012, the number of students increased from 55,600 to 58,100. Numbers have fluctuated during this period.

Figure 44: Number of EU27 graduate students (i.e. students in graduate and professional degree programmes) enrolled at US Universities, 2003-2011



Source: Own calculations based on Institute of International Education. "International Student Totals by Place of Origin", various issues. Open Doors Report on International Educational Exchange

Useful information on the number of individuals born in the EU who were awarded a doctorate in the US can be found in the *Survey on Earned Doctorates.* This survey reports in more detail the number of EU27 born individuals who were awarded research doctorates from US institutions, identified by country of origin for the period 1958-2011.

Table 27 displays these figures for the period 2000-2011. From the decade 1970-1979 to the decade 2000-2009, the total number of EU-born students receiving a research doctorate in US increased by 67% from 12,421 to 20,732.

Table 27: EU27-born US research doctorate recipients, by country of birth in the period 2000-2011

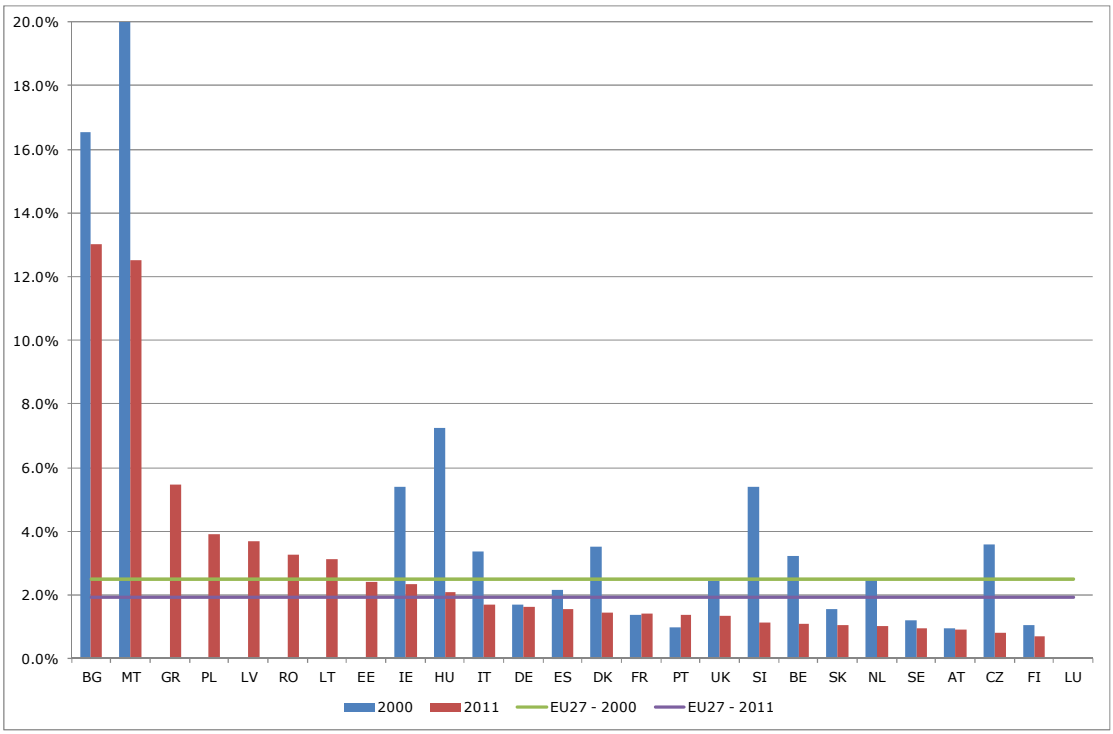
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AT	17	27	22	29	23	21	27	27	29	23	17	22
BE	37	35	35	39	34	37	35	35	32	35	24	24
BG	66	65	58	68	93	98	88	92	118	104	110	83
CZ	32	19	24	34	33	38	37	32	21	19	20	20
DK	28	27	31	25	29	16	14	25	30	25	22	22
FI	19	28	16	24	22	22	17	11	14	11	10	13
FR	144	156	147	146	142	169	172	188	203	189	162	180
DE	436	465	385	429	379	406	418	365	375	413	381	445
GR	113	115	121	105	130	130	154	140	114	150	108	92
HU	52	38	41	42	35	52	48	48	39	31	45	26
IE	27	42	44	47	34	27	41	43	52	24	38	34
IT	136	169	174	180	214	203	228	153	209	177	171	193
LU	3	3	3	3	3	0	3	3	0	0	3	0
MT	3	3	0	3	3	3	3	3	3	3	3	3
NL	62	66	51	44	57	50	50	48	40	47	40	38
PL	70	77	67	68	76	91	113	113	101	129	140	119
PT	25	42	38	36	43	42	36	35	40	25	37	32
RO	137	148	171	170	209	247	243	240	211	217	189	183
ES	131	138	125	152	135	140	117	129	157	131	105	137
SE	37	35	35	28	38	57	32	49	37	31	34	32
SK	7	11	9	14	11	19	16	23	18	15	16	18
SI	16	3	6	7	9	6	10	11	7	10	5	6
EE	0	0	0	0	8	3	6	7	3	3	5	6
LV	0	0	0	0	8	12	14	12	10	7	14	11
LT	0	0	0	0	10	11	12	13	16	6	9	11
UK	285	311	331	296	323	312	279	272	274	294	275	272
EU27	***1,882***	***2,021***	***1,933***	***1,988***	***2,100***	***2,211***	***2,212***	***2,116***	***2,152***	***2,118***	***1,982***	***2,021***

[1] Data for Cyprus is not available.
SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013).

Between 2000 and 2011, the number increased from 1,882 to 2,021, corresponding to 7.4%. However this increase has not been steady over the years. In 2011, Germany was the country with the highest number of doctorates awarded (445) followed by Italy (193), Romania (183) and France (180). Several Member States have experienced a reduction in the number of their students gaining a doctorate degree in the US.

Starting from these data we can calculate the number of doctoral graduates in the US as a share of the total number of EU citizens earning a doctoral degree in the same year (Figure 45). In the EU27 as a whole, this share was little less than 2% in 2011 and had gone down from 2.5% in 2000 due to the marked increase in the number of doctoral graduates in the EU over the same period. The Member State with the highest share in 2011 was Bulgaria (about 13%).

Figure 45: Number of doctoral graduates at US colleges and Universities in 2000 and 2011 as a share of citizens of the Member States having attained the doctoral degree in 2000 and 2011, by nationality[1]

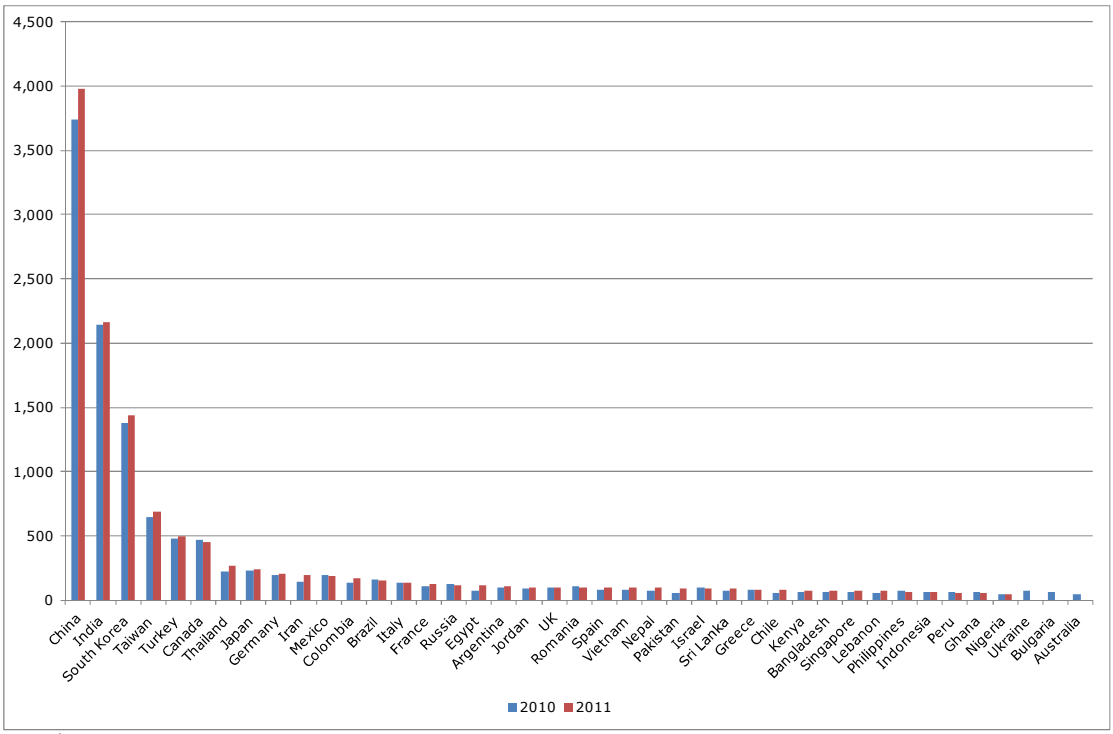


[1] Data for Cyprus are not available; 2000 data are missed for Greece, Poland, Latvia, Romania, Lithuania and Estonia. Member States are ranked according to the 2011 values. The 2000 value for Malta (truncated in the graph) is 41.7%.
Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013) and on EUROSTAT data from the following website: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_grad5&lang=en .

Now we turn to tertiary graduated EU students. Figure 46 reports the top 30 countries of origin of temporary visa holders receiving a doctorate at US Colleges and Universities in 2010. Most of them are Chinese (around 4,000), followed by Indian (over 2,000) and South Korean (almost 1,500) students.

Only a few EU Member States are in the list of the top 30 countries of origin of visa holders enrolled in a doctorate program.

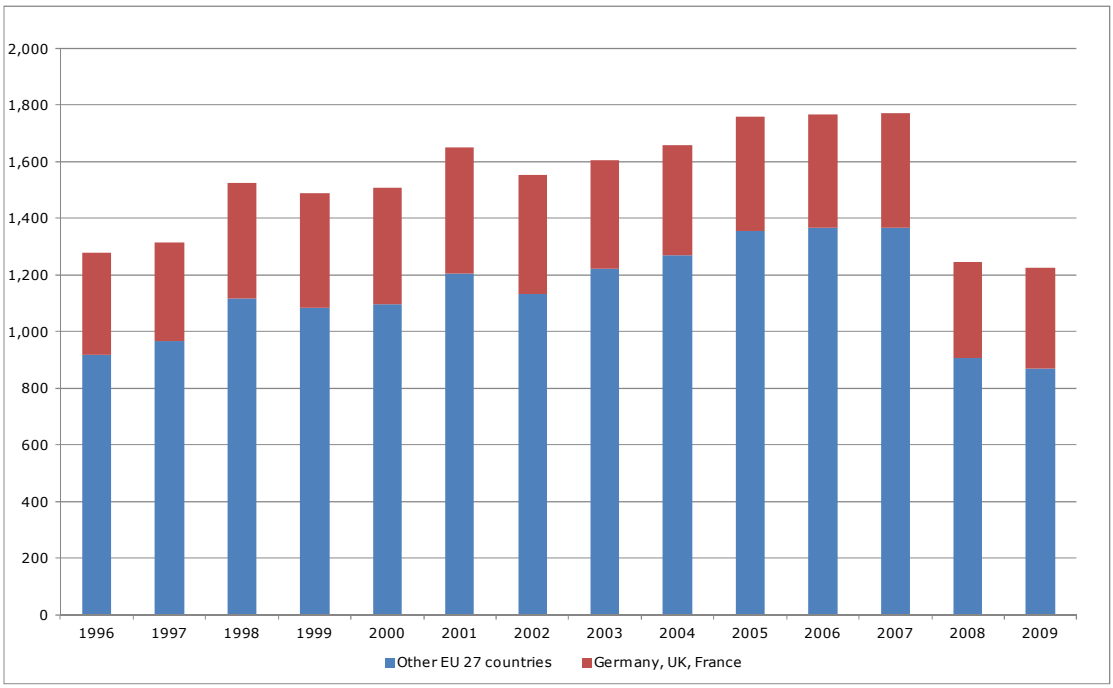
Figure 46: Top 30 countries of origin of temporary visa holders enrolled in a doctorate programme at US colleges and Universities in 2010 and 2011[1]



[1] 2011 values are not available for Ukraine, Bulgaria and Australia.
Source: Own calculations based on NSF/NIH/USED/USDA/NEH/NASA, Survey of Earned Doctorates, 2011.

The data on EU citizens for the period 1996-2009 are reported in Figure 47 where Germany, UK and France are separated from the other EU27 Member States.

Figure 47: Number of US VISA released to EU27 doctoral candidates, by Member State of origin, 1996-2009



Source: Own calculations based on NSF/NIH/USED/USDA/NEH/NASA, Survey of Earned Doctorates, 2011.

The series follows an upward trend until 2007. In the two years which followed, there was a sharp reduction which brought the total to values lower than 1996. It is not easy to explain this decrease, which does not seem to be caused by Germany, the UK or France. The effects of this decline could soon show themselves in the number of EU citizens receiving a doctorate in the US. It will therefore be of particular interest, also in this respect, to analyse the data in the next Surveys on Earned Doctorates.

7 MOBILITY OF POST-DOCTORAL CANDIDATES

7.1 Indicator 10: Stock of European Researchers outside the EU

7.1.1 The data sources available on "researchers"

The datasets including information which is useful in order to gain at least a partial understanding of the phenomenon are listed in Table 28. The datasets are classified according to the typology of "researcher" or student. The countries covered are specified for each of them, as well as the periodicity of the survey and the period for which they are available.

Table 28: Inventory of available data of EU born individuals working abroad as researchers

Country covered	***DATABASE***	***Periodicity***	***Available period***
EU27 Tertiary students abroad			
Australia, Canada, New Zealand, USA	OECD *Foreign/International students enrolled* (based on UNESCO-OECD-Eurostat (UOE) data collection on education statistics, compiled on the basis of national administrative sources, reported by Ministries of Education or National Statistical Offices.	Yearly	2007-2011
Japan	*Eurostat database on Education/* Enrolments, graduates, entrants, personnel and language learning - absolute numbers (educ_isced97)/Foreign students in tertiary education (ISCED 5-6) by country of citizenship (educ_enrl8), http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_enrl8&lang=en	Yearly	2005-2011
USA	*NSF/NIH/USED/USDA/NEH/NASA, Survey of Earned Doctorates* (only the first 40 more important countries)	Yearly	1958-2011
Doctoral candidates			
USA	*National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates*	Yearly	1958-2011
USA	*Institute of International Education. "International Student Totals by Place of Origin"*, Open Doors Report on International Educational Exchange	Yearly	1919-2011
Japan	*Lifelong Learning Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology* (only for France, Germany and UK)	One wave	2011
Australia	*Australian Government; Department of Industry, Innovation, Science, Research and Tertiary Education, "Students: Selected Higher Education Statistics"*	One wave	2011
Doctoral graduates			

USA	*Institute of International Education. "International Student Totals by Place of Origin"*, Open Doors Report on International Educational Exchange	Yearly	1919-2011
USA	*National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates*; special tabulation	Yearly	1958-2011
Visa holders			
Japan	*Lifelong Learning Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology* (only for France, Germany and UK)	One wave	2011
USA	*National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates*	Yearly	1958-2011
Post-doctoral researchers			
USA	*National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates*; special tabulation	Yearly	1968-2011
EU27 Scholars			
USA	*International Education (IIE) "Institutions Hosting the Most International Scholars, various years*." Open Doors, Report on International Educational Exchange.	Yearly	2003-2011
HRST by Occupation			
USA, Mexico, Canada, New Zealand, Australia	*OECD, Immigration database*	One wave	2000

Source: MORE2 Researcher Indicators (2013)

From some of the datasets listed above we can draw information on the stock of EU researchers working abroad. This information is, however, piecemeal, covers only a few years and a few countries and/or does not refer to researchers identified both on the basis of their education and occupation. This is why it is not possible to determine the exact number of European researchers working outside Europe[41].

In the next section, a short overview of the available information on the number of European researchers working outside Europe is provided. For an overview of EU27 tertiary students and doctoral candidates who study/work outside the EU, please see section 6.4 (indicator 9: Mobility of EU27 graduate students out of Europe). The last section provides an overview of the estimates of EU-born researchers working abroad.

[41] See Franzoni *et al.* (2012).

7.1.2 Available information on stock of "researchers" outside the EU

Table 29 shows the flow of the number of EU doctoral candidates in the US, identifying those who effectively remain in the US, having a definite commitment for a research position. However, the data do not specify what kind of job those who stay, actually secure.

On average, an increasing share of EU27-born individuals attaining a doctoral degree in the US remains to work there (28.1% in 2000 and over 40% in 2005 and 2011). In 2011, the highest share is found in Bulgaria, Romania, Greece, Hungary and Sweden. The gap between the number of doctoral graduates and the number of those remaining in the US may depend on several factors (personal reasons for changing their plan; lack of opportunities in the host country; more favourable condition in other countries, including their home country).

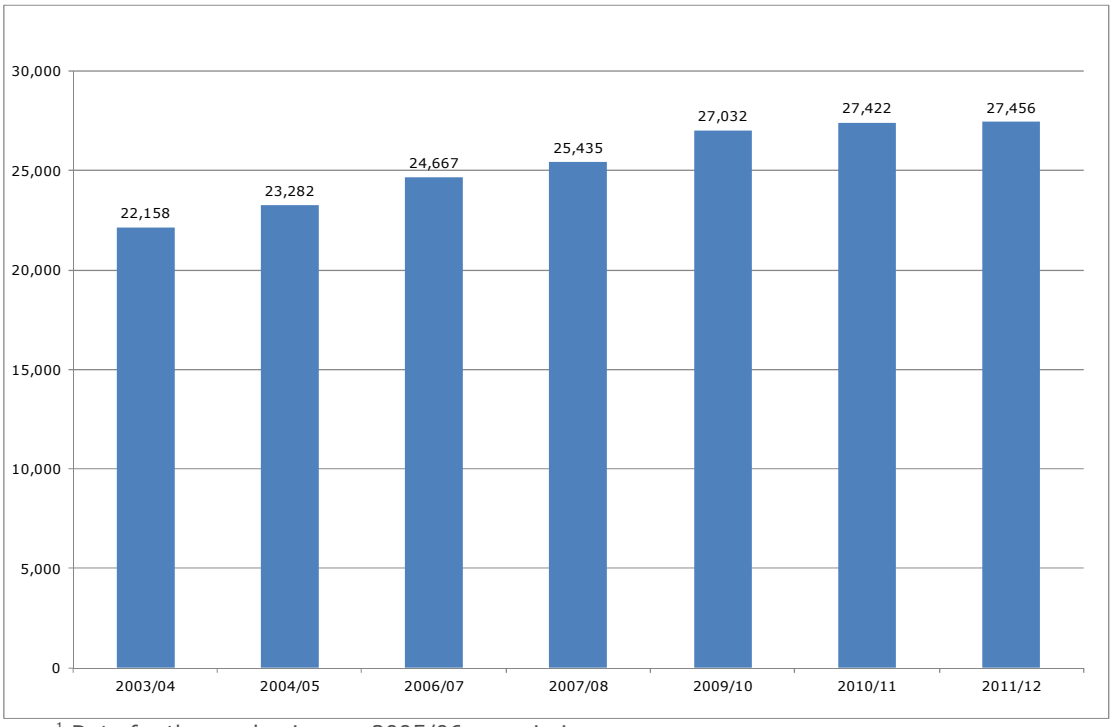
Table 29: European-born US research doctorate recipients and those with definite commitments for research position in the US by EU27 country of birth[1]

	2000			2005			2011		
	Doctoral graduates	**Commit. in US**	**Share**	**Doctoral graduates**	**Commit. in US**	**Share**	**Doctoral graduates**	**Commit. in US**	**Share**
AT	17	3	14.7%	21	11	52.4%	22	9	40.9%
BE	37	8	21.6%	37	18	48.6%	24	7	29.2%
BG	66	21	31.8%	98	46	46.9%	83	39	47.0%
CZ	32	5	15.6%	38	17	44.7%	20	7	35.0%
DE	436	132	30.3%	406	176	43.3%	445	193	43.4%
DK	28	7	25.0%	16	9	56.3%	22	6	27.3%
EE	0	0	n.a.	3	3	83.3%	6	3	41.7%
ES	131	39	29.8%	140	69	49.3%	137	53	38.7%
FI	19	3	13.2%	22	6	27.3%	13	3	19.2%
FR	144	49	34.0%	169	71	42.0%	180	71	39.4%
GR	113	30	26.5%	130	60	46.2%	92	46	50.0%
HU	52	17	32.7%	52	17	32.7%	26	13	50.0%
IE	27	8	29.6%	27	14	51.9%	34	14	41.2%
IT	136	30	22.1%	203	89	43.8%	193	66	34.2%
LT	0	0	n.a.	11	5	45.5%	11	3	22.7%
LU	3	3	83.3%	0	0	n.a.	0	0	n.a.
LV	0	0	n.a.	12	3	20.8%	11	5	45.5%
MT	3	3	83.3%	3	3	83.3%	3	0	0.0%
NL	62	21	33.9%	50	17	34.0%	38	10	26.3%
PL	70	15	21.4%	91	43	47.3%	119	48	40.3%
PT	25	8	32.0%	42	10	23.8%	32	12	37.5%
RO	137	43	31.4%	247	140	56.7%	183	94	51.4%
SE	37	9	24.3%	57	25	43.9%	32	15	46.9%
SI	16	3	15.6%	6	3	41.7%	6	3	41.7%
SK	7	3	35.7%	19	8	42.1%	18	8	44.4%
UK	285	80	28.1%	312	139	44.6%	272	104	38.2%
EU27	***1,882***	***537***	***28.5%***	***2,211***	***1000***	***45.2%***	***2,021***	***830***	***41.1%***

[1] Data for Cyprus are not available.
Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013).

However, from these data alone it is impossible to infer the magnitude of EU researchers in the US. One of the most updated pieces of information on EU citizens employed abroad as researchers is the number of scholars from EU27 countries working in the US (Figure 48). 'Scholars' are defined as someone who, after a long period of study, has profound knowledge of a particular subject in a given branch or field of science. This is a very broad definition which cannot be assumed to correspond to that of all researchers. The trend of scholars in the US is increasing over the whole period, but in the last three years the rise has been relatively small. The stock in 2011/12 is about 27,500.

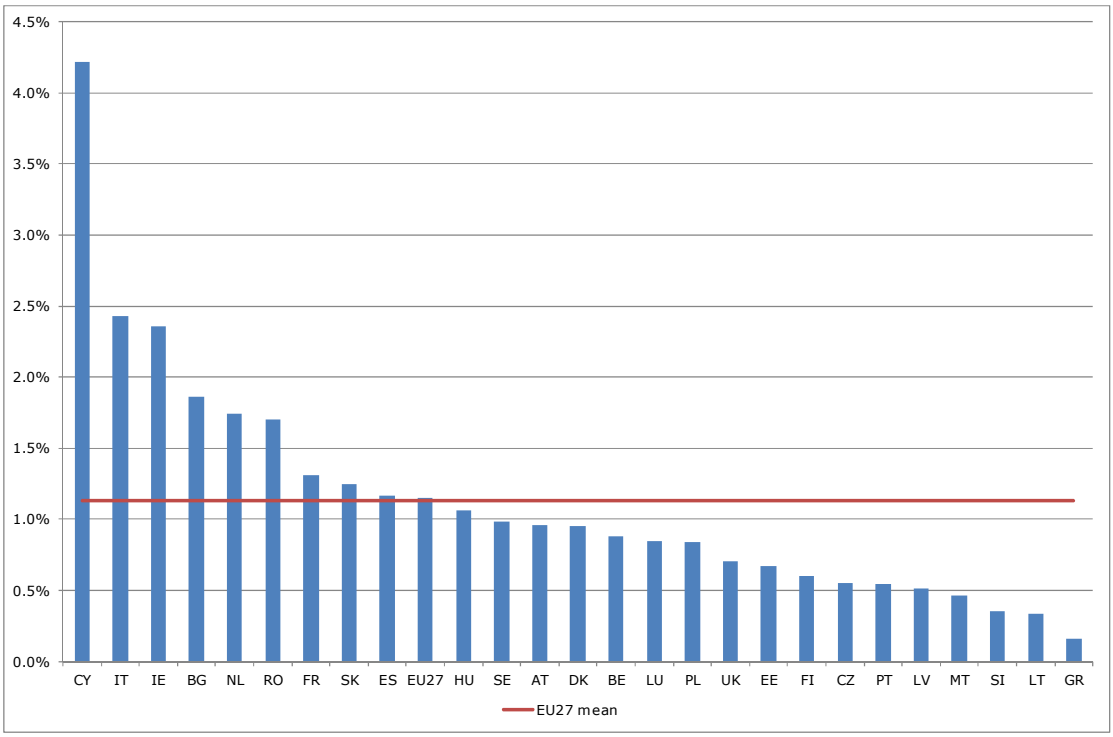
Figure 48: Number of EU27 scholars working in US in various academic years[1]



[1] Data for the academic year 2005/06 are missing.
Source: Own calculations based on Institute of International Education (IIE). (2012). "Institutions Hosting the Most International Scholars, various years." Open Doors, Report on International Educational Exchange.

In Figure 49, the number of EU27 scholars in the US by EU Member State of origin as share of the researchers employed in the Member State of origin, is reported. For the whole EU27 the share is a not negligible 1.15%. Cyprus gets the highest value, but Italy is the first among the big countries (almost 2.5%). Greece shows the lowest share.

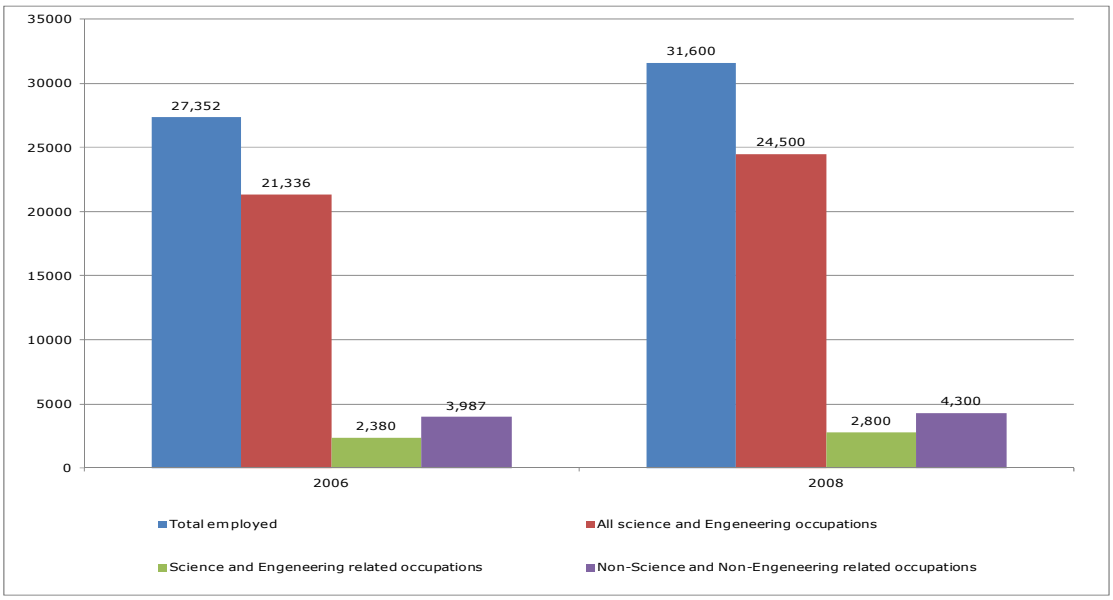
Figure 49: Number of scholars from EU27 Member States employed in US as a percentage of total researchers employed in the Member State in 2009



Source: Own calculations based on Institute of International Education. "Institutions Hosting the Most International Scholars, various years." Open Doors Report on International Educational Exchange.

A further piece of information relates to the number of EU citizens who hold a PhD in Science and Technology and are employed in the US. (Figure 50). This number was 31,600 in 2008, with an increase of more than 4,200 since 2006. The great majority of these doctoral graduates are employed in Science and Engineering related occupations (around 78% in both 2006 and 2008). However we know too little about their occupations to classify all of them as researchers.

Figure 50: Number of EU citizens PhD holder in Sciences and Technology employed in US



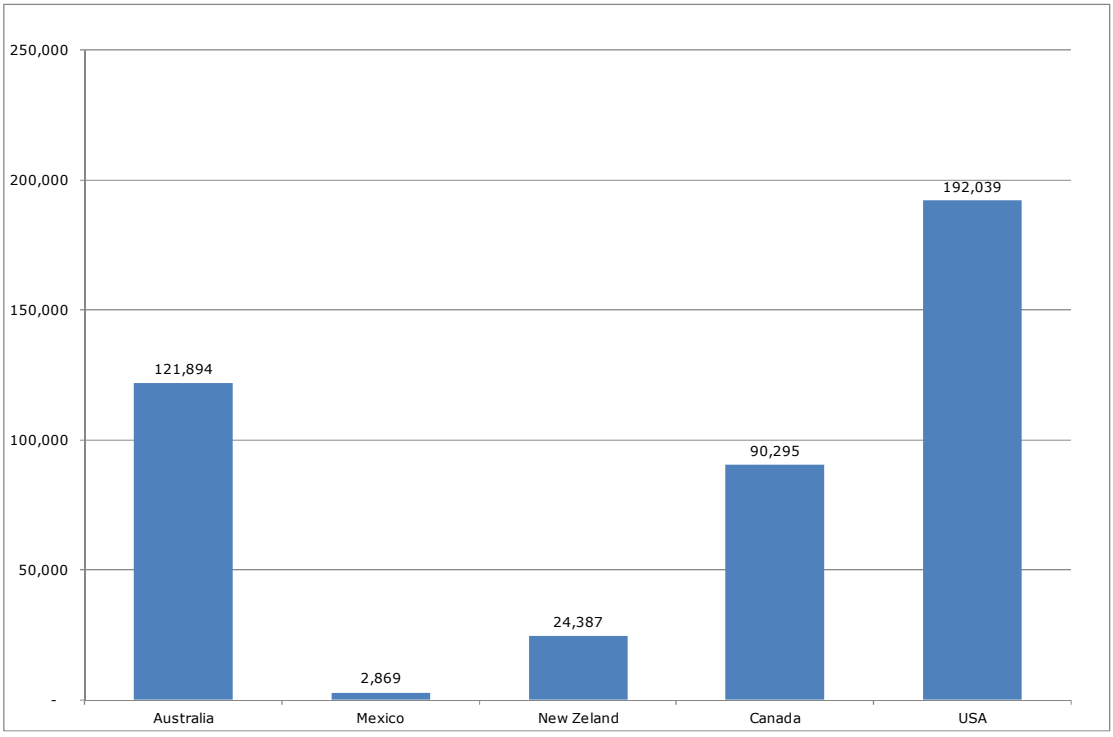
Source: Own calculations based on National Science Foundation/Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT)

The OECD database on International Migration contains information on both the country of birth and occupation of a person residing in a foreign country. Data refer to Human Resources in Science and Technology by occupation (HRSTO). They are obtained by considering all residents in the selected country born in one of the EU27 Member States, who are employed in one of the occupations of the Sciences and Technology field or related to it. Moreover, it covers not only the US but also Canada, Australia, New Zealand and Mexico. This data however also has limitations, particularly the non-availability of such data after 2000 and the lack of information on the level of education.

The data reported in Figure 51 show that the total number of EU citizens with the above-mentioned characteristics numbered over 430,000 in 2000. Almost 45% of them were employed in the US; Australia follows with a share of about 28%.

These data are also insufficient to offer a reliable and relative complete picture of the stock of EU researchers abroad and its trend.

Figure 51: Number of EU27 HRSTO employed in selected foreign countries



Source: Own calculations based on OECD International Migration Statistics (database)

7.1.3 An estimate of the EU born researchers working abroad

As previously noted, there are no data on EU researchers which cover a large number of countries, refer to a long period of time and are based upon a homogeneous definition of "researcher". There is no internationally coordinated survey on this phenomenon and many countries do not collect data. This implies that it is extremely difficult to determine the number of EU-born researchers (by education and occupation) working abroad and their trends over time.

The country for which more and better data are available is the US, but again, there are some difficulties in estimating the stock of EU-born researchers and their trends over time.

Given the lack of data, the stock of EU born researchers working abroad can only be estimated. Our attempt to produce an estimate which is as reliable as possible takes as its starting point important information provided by the Survey of Earned

Doctorates (SED), which is a census of all research doctorate recipients from US institutions[42]. This survey records for each year over the period 1962-2011 the number of doctorate recipients who, at the time they completed the SED, reported: (i) to have "definite commitments" for employment or a post-doc position in the US in the following year, and (ii) that the primary or secondary work activity of this forthcoming position was "research".

These numbers are displayed, after calculating them cumulatively in 5-year periods, in Table 10 (except the first and the last ones that are of different length). At the EU level, a huge increase took place (+326%) between 1970-74 and 2005-2009, the largest rise occurring over the last 10-15 years. However, once again, the performances of each individual Member State has been very different.

Table 30: EU27 Member States born US research doctorate recipients with definite commitments for research position in US after graduation, by country of birth[1], 1962-2011

	1962-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2009	2010-2011
DE	244	269	306	245	306	379	448	625	844	354
UK	146	236	247	256	321	335	376	469	645	219
RO	26	31	33	43	29	27	108	285	603	178
IT	40	54	59	71	101	97	125	249	401	131
FR	46	60	83	70	113	127	147	230	405	130
PL	88	62	65	56	61	84	103	107	244	101
ES	22	20	33	37	53	95	154	228	298	101
GR	94	76	102	134	179	160	160	171	285	91
BG	13	10	10	10	3	8	56	117	248	89
IE	20	26	25	48	32	38	62	60	80	32
NL	59	58	49	49	57	62	86	75	96	30
HU	113	65	32	30	21	28	27	60	82	27
SE	15	13	24	19	28	25	32	41	88	27
PT	5	8	10	13	15	13	24	48	62	26
SK	0	0	0	0	0	0	5	13	47	17
CZ	45	31	28	27	21	17	33	38	59	16
BE	25	25	27	24	40	41	51	52	65	15
DK	18	19	13	17	15	14	15	41	50	14
AT	71	48	46	32	28	30	29	30	56	12
LV	0	0	0	0	0	0	0	3	23	11
FI	13	8	13	13	13	15	13	22	28	5
SI	0	0	0	0	0	0	3	13	19	5
EE	0	0	0	0	0	0	0	3	16	5
LT	0	0	0	0	0	0	0	3	21	5
LU	5	3	0	3	5	8	5	8	5	3
MT	3	0	3	8	3	8	5	10	13	0
EU27	***1,105***	***1,117***	***1,205***	***1,202***	***1,440***	***1,607***	***2,065***	***2,996***	***4,781***	***1,643***

[1] Data for Cyprus are not available. Member States are ranked according to 2010-2011 values.
Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013).

It is interesting to note that the growth rate of these numbers exceeds by far the growth rate of the EU born who earned a doctorate in US. The implication is that a growing share of the latter secured a job as researcher in the US: from the 1970's to the first decade of this century this share approximately doubled, increasing from 18.8% to 37.5%.

[42] See http://www.nsf.gov/statistics/srvydoctorates/

All these data are annual flows. On the contrary, we are interested in the stocks of EU-born researchers working in the US. To transform these flows into stocks we need to know:

a. how long does the job last and what comes after its termination (another job as researcher in US or abroad or in Europe? Any other job? Retirement?);
b. how many EU-born researchers who did not earn their doctorate in US get a job as researcher in this country and how long did that job last?

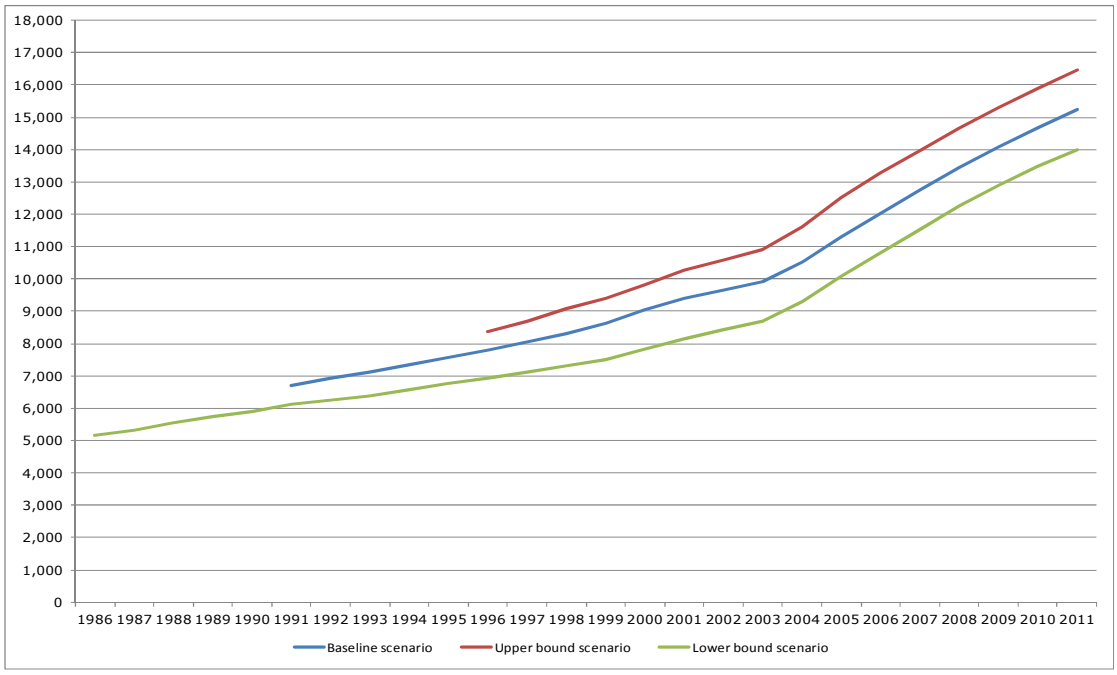
Having no possibility of getting accurate information on these two aspects, we make the following assumptions:

i) the post-doctoral career lasts for 30 years (our "baseline" scenario), or alternatively for 25 years (the "lower bound" scenario) or for 35 years ("upper bound" scenario);
ii) the numbers of outflows (EU citizens moving away from US) and inflows (EU researchers moving to US after completing the doctorate) are equal over the period of observation. It should be noted that compared to the "baseline" scenario, the "lower bound" scenario is consistent with outflows larger than inflows (and vice versa in the case of the "upper bound" scenario).

On the basis of these assumptions, with annual data available from 1962 up to 2011, the trend for the stock of EU-born researchers in US can be estimated for the period 1991-2011 (where 1991, in the "baseline" scenario represents the cumulated flows of the 30 years period from 1962 to 1991, 1992 that of the period 1963-1992, etc…, while the cumulated periods will be 25 and 35 years in the two other scenarios).

The results of our estimates in the three scenarios are displayed in Figure 52 and in Table 31.

Figure 52: Estimated stock of EU27 born researchers in the US in three different simulation scenarios



Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013).

Referring to the "baseline" scenario, the stock is estimated to have increased from 9,045 in 2000 to 15,239 in 2011, with a steady increase year after year. The overall rate of increase in this 12-year period is estimated to be 68.5%, corresponding to an average yearly increase of about 4.5%.

In the "lower bound" scenario the absolute numbers are lower but their rate of increase is bigger (79% over the whole period). Of course, the opposite holds in the "upper bound" scenario.

Starting from these estimates on the stock of EU- born researchers working in the US, we can also attempt to reach an estimate of the EU-born researchers working in other countries. To accomplish this, given the lack of data, we need to make further assumptions:

We start from the stock of EU-born HRST working in US, New Zealand, Australia, Canada and Mexico. These stocks are made available by the OECD for year 2000, with no recent updates. Our strategy consists of the following two steps:

i) to calculate the stock of EU-born researchers working in US in 2000 (estimated above) as a share of the stock EU-born HRST working in the US in that same year;
ii) to apply the resulting ratio to the four other countries, on the assumption that in each of them basically the same share of EU-born doctorate recipients gets a job as researcher as in US;
iii) to apply to the resulting estimated stock of researchers in 2000 the same rate of growth of the stock of researchers we calculated in US between 2000 and 2011.

Table 31: Estimated stock of EU27 born researchers in the US in three different simulation scenarios in the period 2000-2011

	Lower bound scenario	Baseline scenario	Upper bound scenario
2000	7,820	9,045	9,817
2001	8,159	9,413	10,255
2002	8,437	9,663	10,598
2003	8,698	9,909	10,909
2004	9,308	10,513	11,630
2005	10,068	11,279	12,504
2006	10,801	12,024	13,278
2007	11,529	12,742	13,968
2008	12,245	13,458	14,669
2009	12,888	14,089	15,294
2010	13,462	14,662	15,873
2011	13,997	15,239	16,462

Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates; special tabulation (July 2013).

According to our data, around 190,000 EU-born HRST worked in US in 2000, while our calculations estimate a stock of EU-born researchers in US between 7,820 and 9,817 (in the three simulations scenarios). The estimated share of researchers on total HRST in 2000 in the US is then between 4.1% and 5.1% and equal to 4.7% in the baseline scenario.

Applying these shares to the number of HRST working in 2000 in the four other countries, we compute the stocks of EU-born researchers in New Zealand, Australia, Mexico and Canada in 2000.

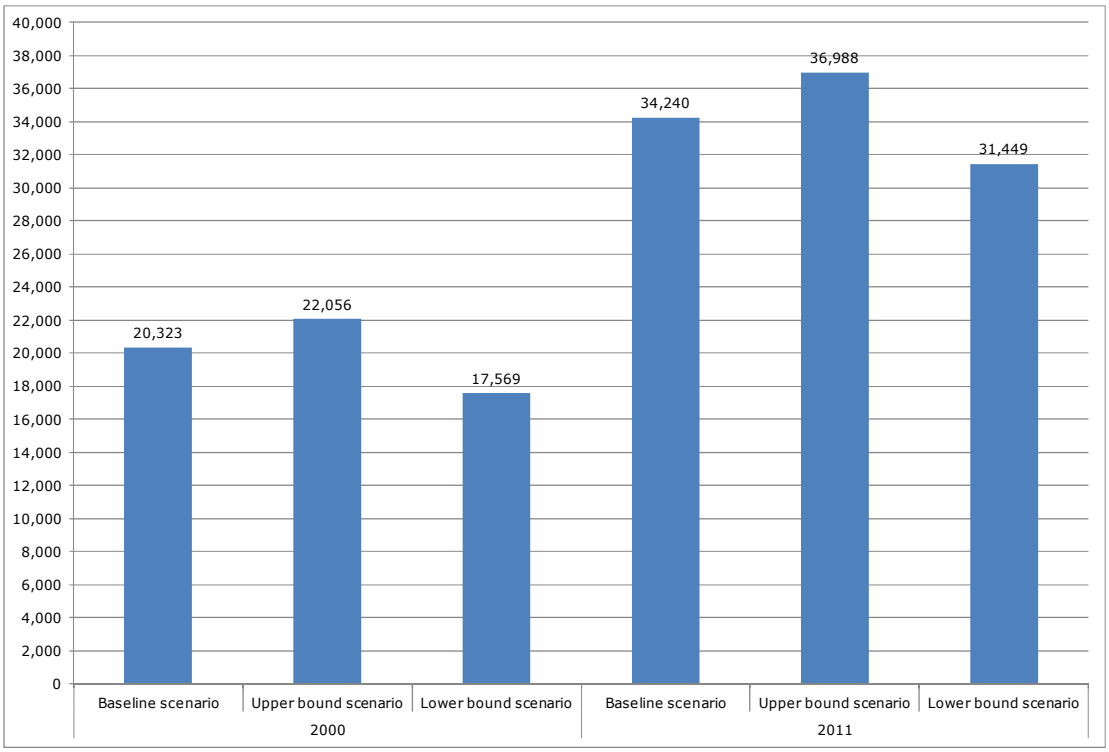
Finally, the stock of EU-born researchers in these four countries has been updated to 2011, applying the growth rate of the stock of EU born researchers in US in the period 2011-2000 (around 70%). Table 32 and Figure 53 display the resulting figure for 2000 and 2011.

Table 32: Estimated stock of EU27 born researchers in US, AUS, NZL, CAN and MEX in three different simulation scenarios in 2000 and 2011

	2000			2011		
	Lower bound	Baseline	Upper bound	Lower bound	Baseline	Upper bound
US	7,820	9,045	9,817	13,997	15,239	16,462
Australia	4,963	5,741	6,231	8,884	9,673	10,449
Canada	3,677	4,253	4,616	6,581	7,165	7,740
New Zealand	993	1,149	1,247	1,777	1,935	2,091
Mexico	117	135	147	209	228	246
Total	***17,569***	***20,323***	***22,056***	***31,449***	***34,240***	***36,988***

Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates - special tabulation (July 2013) – and on National Science Foundation/Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT)

Figure 53: Estimated stock of EU27 born researchers working in 5 non-EU countries (US, AUS, NZL, CAN and MEX) in three different simulation scenarios in 2000 and 2011



Source: Own calculations based on National Science Foundation, National Center for Science and Engineering Statistics, NSF/NIH/ED/USDA/NEH/NASA Survey of Earned Doctorates - special tabulation (July 2013) – and on National Science Foundation/Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT)

In particular, according to these estimates and assuming the "baseline" scenario, the total number of EU-born individuals working as researchers in 2011 in US, Australia, New Zealand, Canada and Mexico was around 34,000.

We emphasise, once again, that these are estimates based on disputable, though not unreasonable, assumptions.

The methodology we have used can yield better results once reliable data become available on one or another of the assumptions we have made. A definite knowledge of the magnitude and the trend of the stock of EU researchers abroad needs better and more complete data.

7.2 Indicator 11: "More than 3 months mobility"

This indicator refers to EU researchers in Higher Education Institutions having been internationally mobile for a period longer than three months.

In WP1 this indicator is presented and thoroughly analysed in sections 5.6.2-5.6.3 where all the sub indicators are also discussed. They are presented particularly with respect to the following researchers' characteristics:

- citizenship;
- the career stage (if R1, R2, R3 or R4);
- field of science;
- to timing (if in the last ten years; if more than ten years ago);
- country of destination;
- gender and family status.

This topic is also analysed in WP2, but from a different point of view. The subject of study of WP2 is researchers in Higher Education Institutions outside EU. In that survey researchers are divided into four main categories:

- EU researchers currently working abroad;
- Non-EU researchers who had been in the EU in the past;
- Non-EU researchers who had never been in the EU but who had been in non-EU countries;
- Non-mobile non-EU researchers.

Given the non-representativeness of the sample we decided not to take into consideration the indicators produced by these WP2[43].

7.3 Indicator 12: "Less than 3 months Mobility"

This indicator refers to EU researchers in Higher Education Institutions having been abroad for less than 3 months in the last ten years.

In WP1 the indicator is presented and analysed deeply in section 5.6.4 where all the sub indicators are also discussed. They are presented particularly with respect to the following researcher characteristics:

- citizenship and country where the highest educational degree was attained;
- career stage, i.e. PhD degree mobility, during PhD mobility, post PhD mobility;
- field of science;
- gender and family status;
- type and frequency;
- duration.

7.4 Indicator 13: Employer mobility

The term "Employer Mobility" refers to researchers who have been mobile for more than three months in the last ten years and for whom at least one move involved a change in employer.

In WP1, this indicator is calculated for researchers in EU Higher Education Institutions at the career stages R2 to R4. This indicator, per country and per career stage, is presented and discussed in WP1 report[44]. The type of contract when undertaking the move is also taken into consideration, as is the duration of the move and the promotion or career progression made during that period.

[43] Idea Consult et al, 2013c

[44] See Idea Consult et al, 2013b

7.5 Indicator 14: Inter-sectorial mobility - Share of Higher Education Institutions researchers with experience in private sector in the last ten years

This indicator has been obtained with data from the ad hoc survey targeted at researchers currently employed in Higher Education Institutions[45]. Thus, those researchers who moved to a private employer and did not return to Higher Education Institutions are not considered in the analysis.

The results obtained have been reported while taking into consideration the country of current employment, the destination sector, the researcher's gender, the field of science, the career stage at which it happened and whether it meant a dual position or not.

7.6 Indicator 15: Barriers to international mobility

This indicator shows the main factors hampering the mobility of researchers across borders in Europe and refers to EU researchers in Higher Education Institutions having been or not having been mobile during their career at any stage.

The obstacles were analysed applying different points of view:

- Barriers experienced in moving to the EU by non-EU researchers currently working in the EU;
- Barriers indicated which actually prevent the researchers from taking part in all doctoral degrees in another country (among the non-mobile);
- Barriers experienced as important to be overcome by researchers in their last move;
- Barriers indicated as actually discouraging researchers from becoming internationally mobile (among the non-mobile).

In WP1, this indicator is presented and analysed deeply in section 5.6.8 where all the sub indicators are also discussed. The following elements are specifically highlighted:

- Importance of barriers for non-EU27 researchers currently working in the EU27+3 (i.e. the Three Candidate Countries);
- Barriers for non-EU27 researchers currently working in the EU 27+3 per current career stage (i.e. for PhD degree, during PhD, post PhD, distinguishing R2-R4).

7.7 Indicator 16: International non-mobility

This indicator refers to EU researchers in Higher Education Institutions not having been internationally mobile during their career at various stages (for PhD degree, during PhD or post PhD, distinguishing R2-R4).

In WP1, this indicator is presented and analysed deeply in section 5.6.7 where all the sub indicators are also discussed. The following relevant sub indicators are presented, particularly:

- Share of never mobile researchers for PhD degree or during PhD, by country of attendance of PhD;
- Share of never mobile researchers in post PhD stage of career per country of citizenship.

This indicator is better analysed when considered together with the previous one regarding the barriers to international mobility.

[45] See Idea Consult et al, 2013b

Part 3 COLLABORATION OF RESEARCHERS

8 INTERNATIONAL COLLABORATION

In this section we present the indicators on international collaboration, virtual mobility and collaboration output.

These indicators provide insights into the degree of international collaboration and the outputs thereof, but also into the importance of mobility in increasing international collaboration. Virtual mobility is added as a new indicator. This terminology is increasingly used in studies and policy documents and refers to a phenomenon which has the potential to substantially affect physical international mobility and the intensity of research collaboration.

8.1 Indicator 17: Percentage of researchers having some form of collaboration with researchers from other EU or extra EU countries

This indicator gives information on the percentage of researchers collaborating with colleagues employed in various sectors.

The collaboration specifically considered in this section are those among researchers in the Higher Education Institution sector in one of the EU Member States, with colleagues residing in others EU or non-EU country.

The sub indicators are considered:

- by gender;
- by country of current employment;
- by stage of career;
- by sector of collaboration.

This indicator is discussed in detail in Section 5.7 of the MORE2 EU HEI Survey report[46].

8.2 Indicator 18: Share of Higher Education Institutions researchers that consider virtual mobility as substitute for short or long term mobility, by FOS.

Virtual mobility refers to situations in which the exchange of knowledge or collaboration between researchers is made possible through the use of the World Wide Web (i.e. Internet), or more generally through the use of TLC devices thanks to the deep technological advancements of the last thirty years. Often, this type of mobility functions as a substitute for short term mobility and it might precede or follow long-term mobility periods.

The share of researchers in Higher Education Institutions who have been internationally mobile and who consider virtual mobility a means to partially substitute physical mobility is reported.

[46] Idea Consult et al, 2013b.

Sub indicators are built with respect:

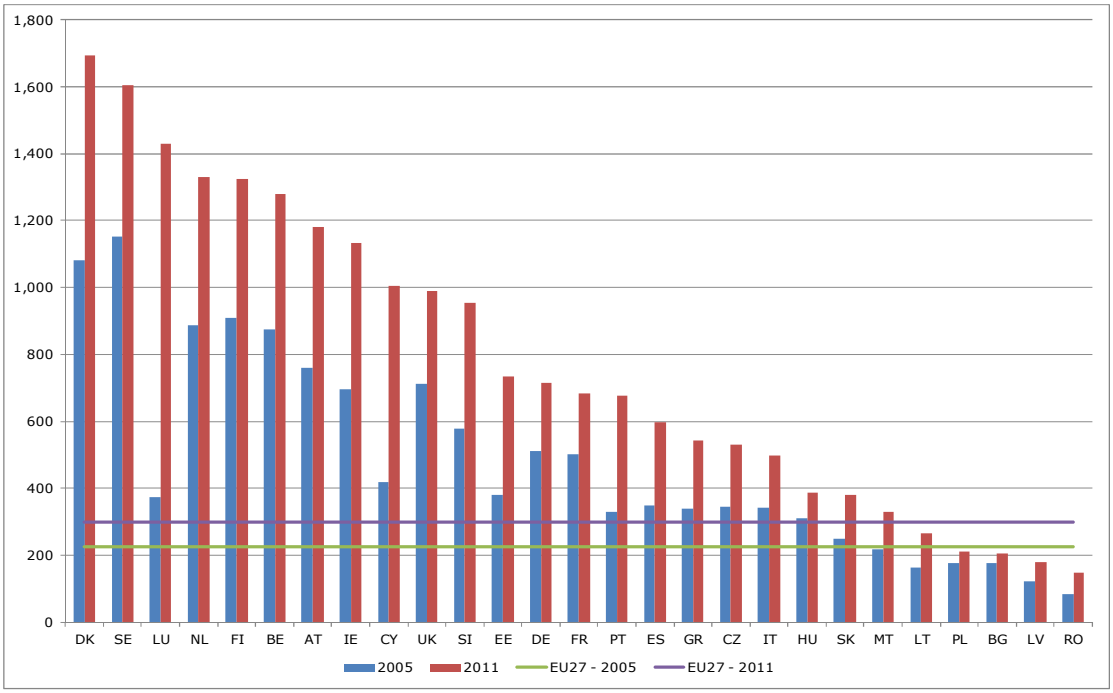
- to gender;
- to the length of physical mobility considered substitutable by virtual mobility;
- to the career stage of respondents.

8.3 Indicators 19: Percentage of co-publications of European researchers with an author from another country

International scientific co-publications can be used as a proxy for the quality of scientific research as collaboration increases scientific productivity[47]. In the Indicator 19, the numerator refers to the number of scientific publications with at least one co-author based abroad (where abroad is another EU Member State or a non-EU country). The denominator is country's total population. In 2011, the EU27 average was around 300 co-publications per million of population and its values have increased significantly since 2005 (as shown in Figure 54).

The EU27 average is relatively low as, here, only co-publications with non-EU countries are included. Nordic countries i.e. Denmark, Sweden and Finland (in descending order) show more than 1,000 co-publications per million in the population. The lowest number (<500) of co-publications per million in the population is recorded in some of new Member States, as Czech Republic, Hungary, Slovakia, Lithuania, Bulgaria, Poland and Romania (in descending order).

Figure 54: International scientific co-publications per million population in 2005 and 2011



Member States are ranked according to the 2011 values.
Source: Own calculations based on IUS (2013)

47 See IUS (2013).

8.4 Indicator 20: Scientific publications among the 10% most cited publications worldwide

Regarding the scientific quality of research worldwide, a very important indicator is the capacity to produce scientific publications with high international impact.

Indicator 21, calculated as the number of citations that scientific articles produced in a country obtain worldwide, in percentage of total scientific publications of the country, can give an idea on the quality of research carried out in that country.

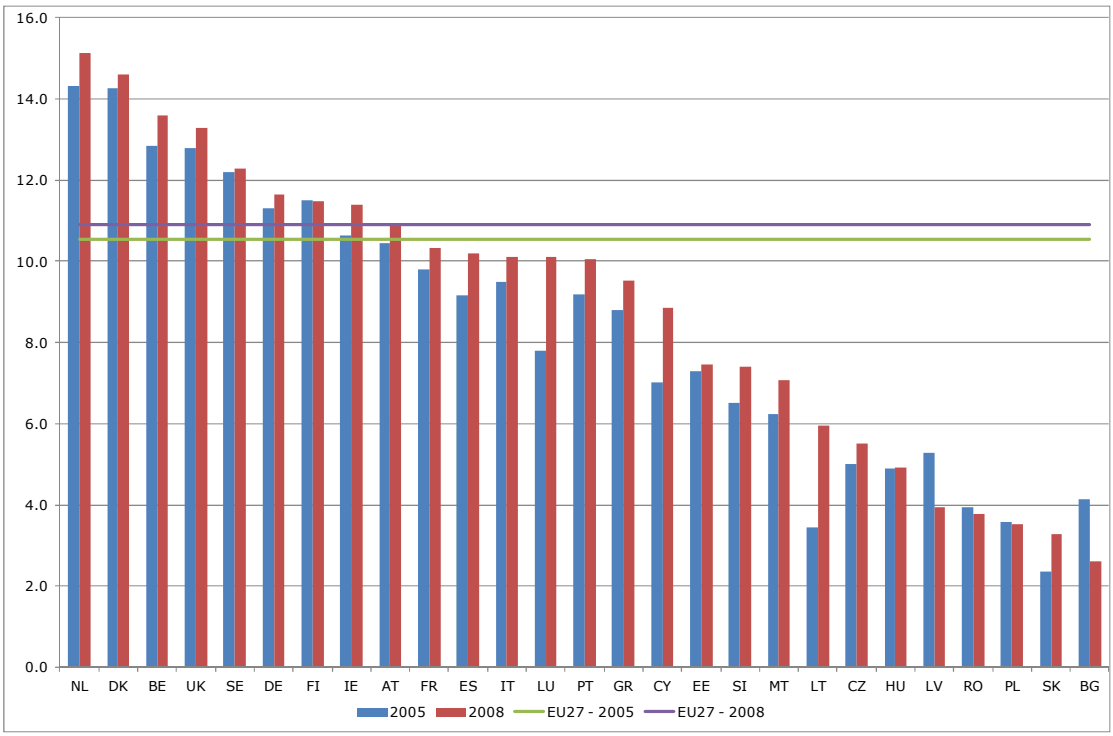
The number of citations that a scientific publication generates is an indication of its excellence and its chance of generating further scientific results. On average, a country is expected to have 10% of its publications among the top 10% most cited worldwide[48]. A value higher than 10% means that the country tends to produce oft-cited publications more frequently than the average.

Indeed, Figure 55 shows the top 10% most cited publications worldwide as percentage of total scientific publications of the country in 2005 and 2008.

The EU27 produced around 11 scientific publications in the top 10% most-cited publications worldwide and this value slightly increased since 2005. Among the EU Member States, the Netherlands lead, followed by (in descending order) Denmark, Belgium, the UK, Sweden, Finland, Austria, Germany, Ireland and France.

However, countries like France and Germany, where researchers publish relatively more in their own language, are more likely to underperform on this indicator as compared to their real academic excellence.

Figure 55: Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country in 2005 and 2008



Member States are ranked according to the 2008 values.

Source: Own calculations based on IUS (2013)Working conditions of researchers

48 See EC DG Research and Innovation (2012).

9 Working conditions of researchers with respect to contract and position and with respect to gender

Working conditions of researchers within the EU27 are relevant to understanding the reasons why European researchers chose to stay or to leave their country. There are several aspects of working conditions which can induce a researcher to change their employer or even their country of employment. These refer not only to salary or work-load, but also to the researcher's level of autonomy in carrying out research, facilities for doing research, the possibility of career and so on. In order to adopt the right policies to make research in Europe attractive for European and non-European researchers, we need to have a better understanding of the working conditions and satisfaction levels of European researchers.

In this section we present a number of indicators that shed light on the situation of European researchers for issues such as the type of contracts they have at various stages of their career; the positions they hold across different fields of science and by gender; and the difference in career progression between women and men. Particularly with respect to gender, the indicators show that positive progress is being made, albeit slowly. It will take decades to close the gender gap and bring about a higher degree of gender equality in the absence of proactive policies. The following indicators can help us to get the necessary knowledge to move in the right direction.

The issues analysed in this section concern the contractual position of researchers in Higher Education Institutions.

9.1 Indicator 21: Share of researchers with different types of contract

This indicator focuses on the share of researchers holding a permanent contract (or a tenured position) compared with those holding a temporary position. The length of contract has been classified into four groups:

- Less than 1 year;
- 1-2 years;
- 2-4 years;
- more than 4 years.

The indicator is presented distinguishing the following categories:

- by stage of career;
- by country of employment;
- by gender

This indicator is discussed in section 5.3 of MORE2 EU Higher Education Institutions Survey report.

9.2 Indicator 22: Share of researchers with different positions by FOS and by gender

The type of position held by researchers in Higher Education Institutions in the EU is presented by this indicator. The types of position considered are: full-time, part-time at more than 50% of the normal time, part-time at 50% of the normal time, part-time at less than 50% of the normal time.

Unexpectedly, gender does not seem to play a particular role here, thus the only sub-indicator presented is by country of current employment. This indicator is discussed in section 5.3.2.3 of MORE2 EU Higher Education Institutions Survey report.

9.3 Indicator 23: Share of women researcher in Higher Education Institutions by grade (A, B, C)

Vertical segregation[49] in the academic world is illustrated by Figure 56. At the first two levels of University education (students and graduates of largely theoretically-based programs to provide sufficient qualifications for gaining entry to advanced research programs and professions with high skills requirements), 55% and 59 % of enrolled students are female in 2010, respectively (Figure 56).

However, men outnumber women as of the third level (doctoral candidates) at which the proportion of female students enrolled drops back to 49%. The gender gap widens at the doctoral graduation level. Indeed, women comprise only 46% of doctoral graduates. The doctoral degree is often required to start an academic career, which means that the decrease of women at this level will have a knock-on effect on their relative representation at the first stage of the academic career.

Women account for only 44% of grade C academic staff (the first grade/post into which a newly qualified doctorate graduate would normally be recruited). The take-off phase in the academic career is consequently also more hazardous for women, as shown by the fact that their proportion drops to 37% among grade B academics (researchers working in positions not as senior or as top position, but more senior than newly qualified doctoral holders). The proportion of women is the smallest at the top of the academic hierarchy, falling back to just 20% of grade A academic staff in 2010 (the highest grade/post at which research is normally conducted).

Off the starting blocks, girls do well, they form a majority in the population of ISCED 5A students and graduates, but the problems begin once they reach the doctoral preparation stage and the other levels which open the way to academic and research careers; the pipeline leaks, and at the very top, at grade A, where we are left with just 20% of women. Although women's share increases over time at all levels, policies are needed to increase the pace of women catching up.

A comparison between 2002 and 2010 shows an improvement in women's relative position at all levels, particularly from PhD through the different stages of the academic career, as captured by grades A, B and C.

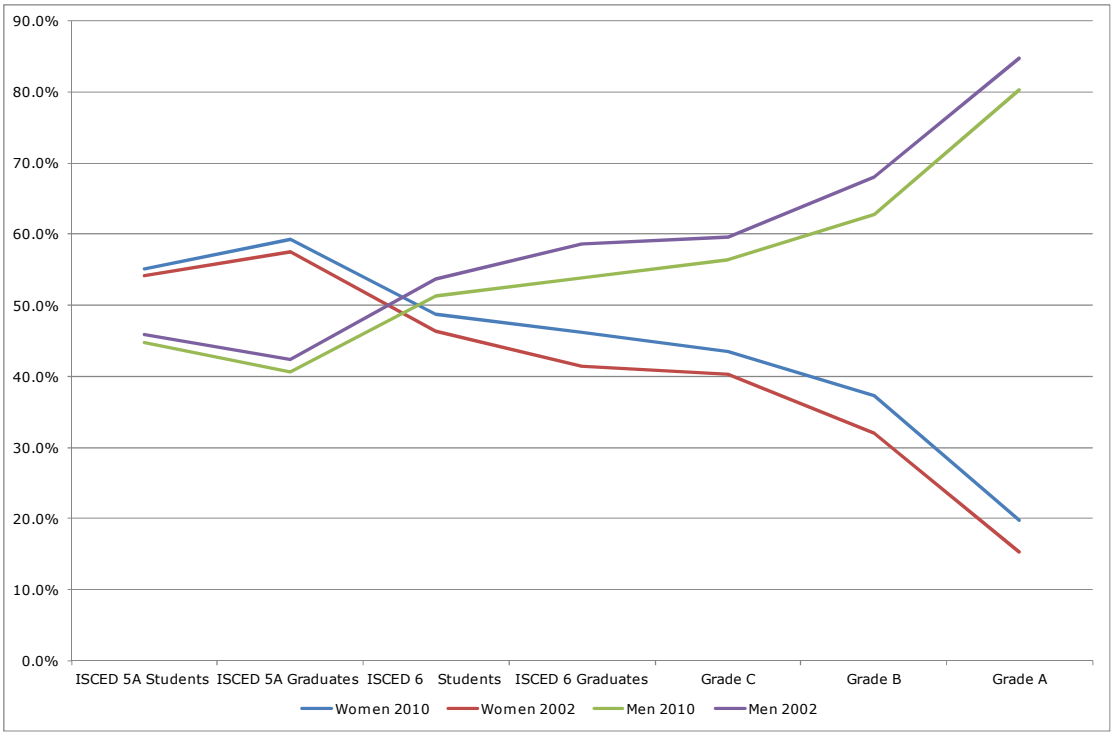
Although a picture of strong vertical segregation transpires through the analysis of the overall situation in the academic world, the situation can vary considerably according to the field of science considered.

[49] Vertical segregation refers to the under (or over) representation of a clearly identifiable group of workers in occupations or sectors at the top of an ordering based on 'desirable' attributes – income, prestige, job stability etc, independent of the sector of activity.

In Science and Engineering, among students and academics, women form a minority. As shown by Figure 57, Science and Engineering remain an overwhelmingly male field. The lack of appeal of Science and Engineering studies for young women is relatively more problematic at the earliest stage of a typical academic career, as women tend to be better represented among doctoral candidates and graduates.

A comparison between 2002 and 2010 points towards an improvement in the proportion of female scientists and engineers that is slightly less pronounced than for all study fields taken together, but for this field of science the lines do not cross, as shown in Figure 57.

Figure 56: Proportions of men and women in a typical academic career, students and academic staff, EU27 in 2002 and 2010

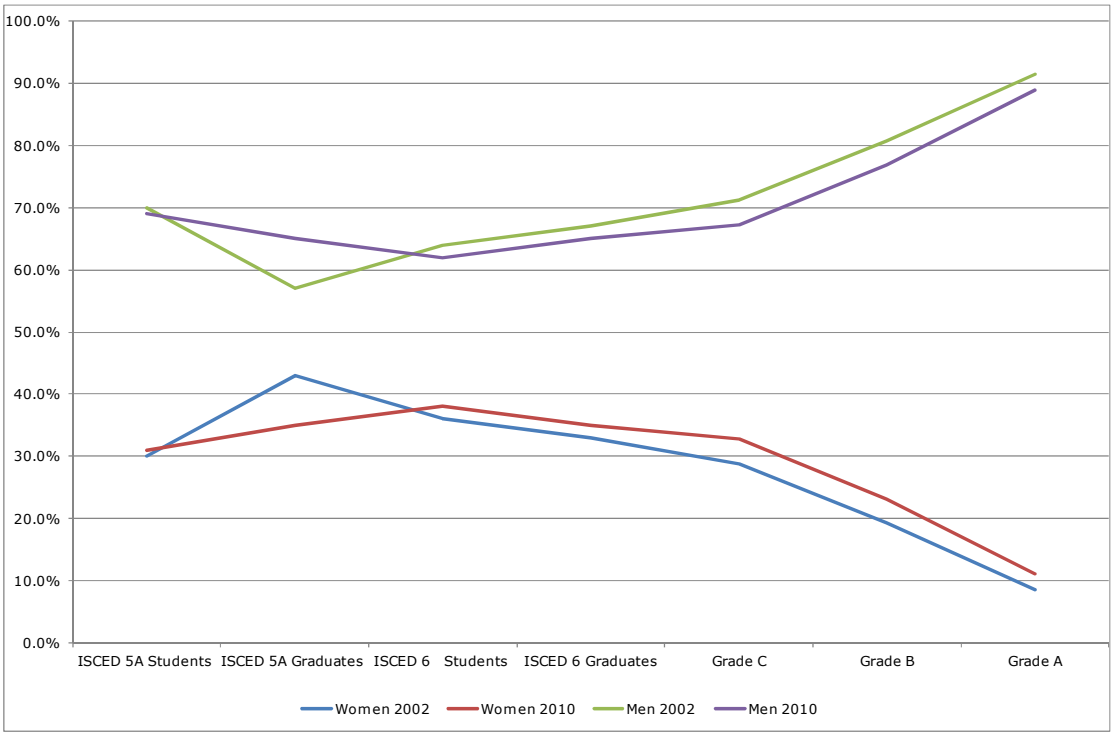


Source: our calculations based on She Figures (2012)

Looking at the percentage of full female professors (grade A) in each Member State (Figure 58), the tendency of most of the Eastern European Member States to have a higher share of women in the top position when compared with the rest of the Union emerges immediately. Romania and Latvia, with 36% and 32% respectively of women in grade A are well above the EU27 average, equal to 20%. Bulgaria, Finland, Slovakia, Portugal, Hungary, Slovenia, Italy and Sweden also have a higher proportion of women in the top position than the EU27 average. Belgium, Luxemburg and Cyprus are, among EU27 countries, those with the lowest percentages. Among the non-EU27 shown in Figure 59 all but Israel have women in top positions in academia in a proportion higher than the EU27 average.

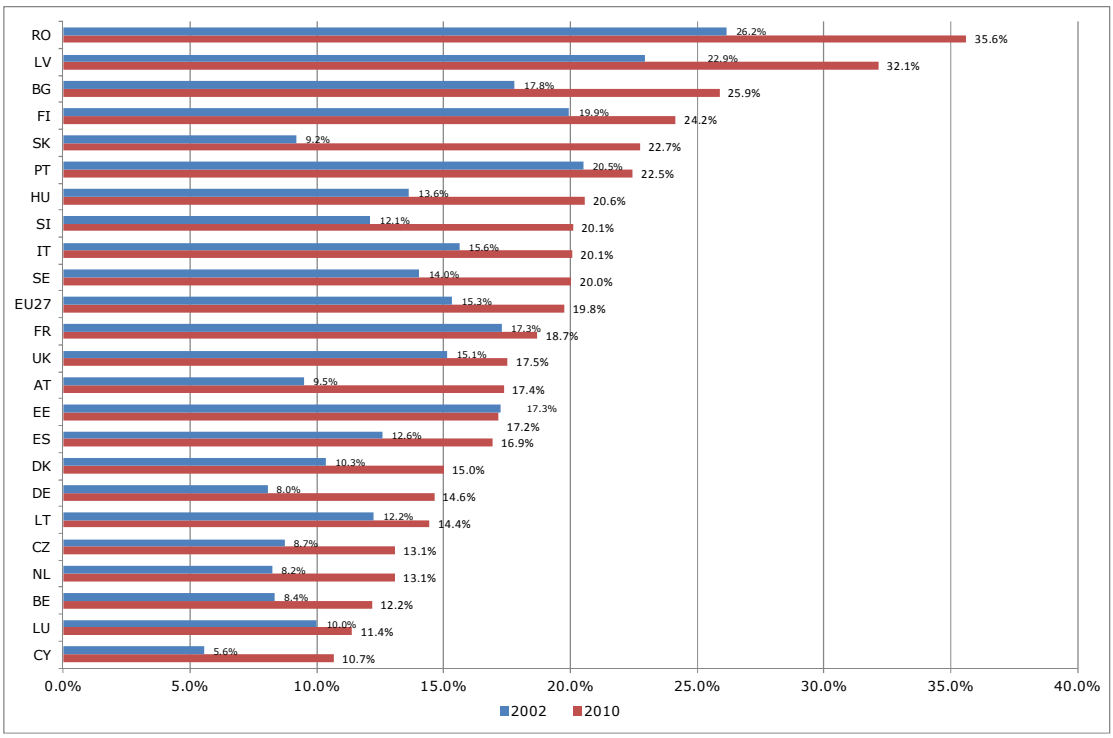
Even if in each of the countries analysed (EU Member States and non-EU countries), the percentage of women at the top of their profession is far from reflecting gender equality, the increase which characterizes the trend in all countries leaves room for hope of more equality in the future. This will make the research career more appealing to women and, moreover, will enrich the research environment.

Figure 57: Proportions of men and women in a typical academic career in science and engineering, students and academic staff, EU27 in 2002 and 2010



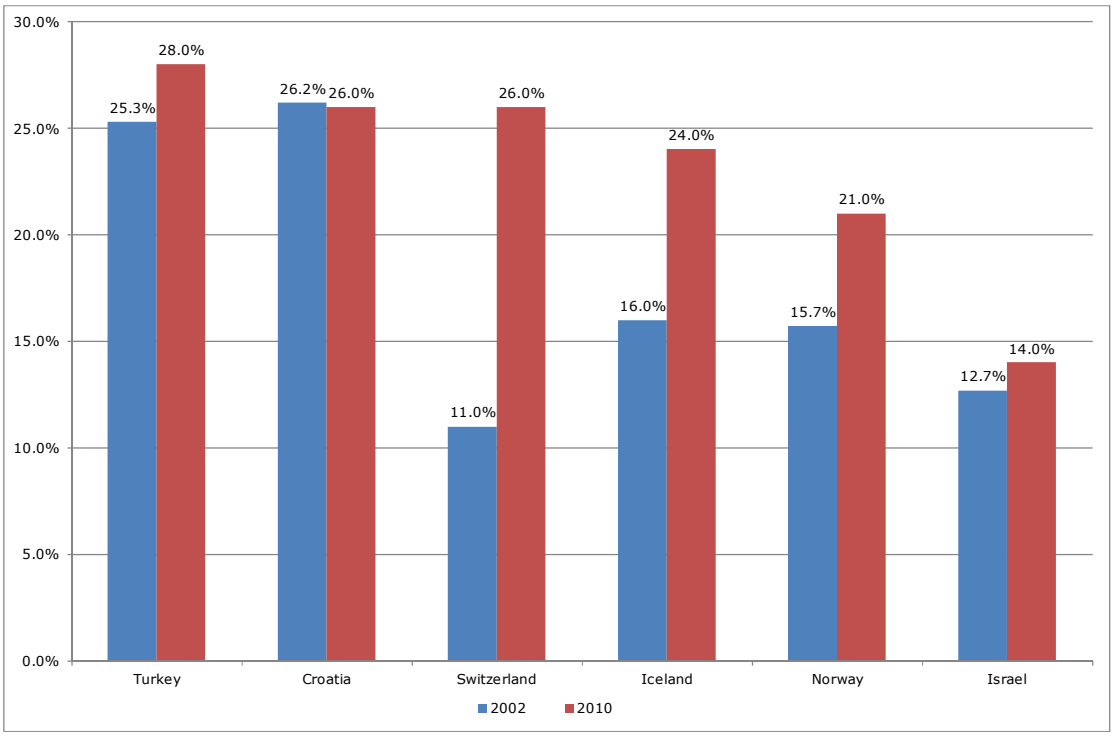
Source: our calculations based on She Figures (2012)

Figure 58: Percentage of women in grade A academic position in EU27 Member States in 2002 and 2010



Source: our calculations based on She Figures (2012)

Figure 59: Percentage of women in grade A academic position in selected non-EU27 countries in 2002 and 2010



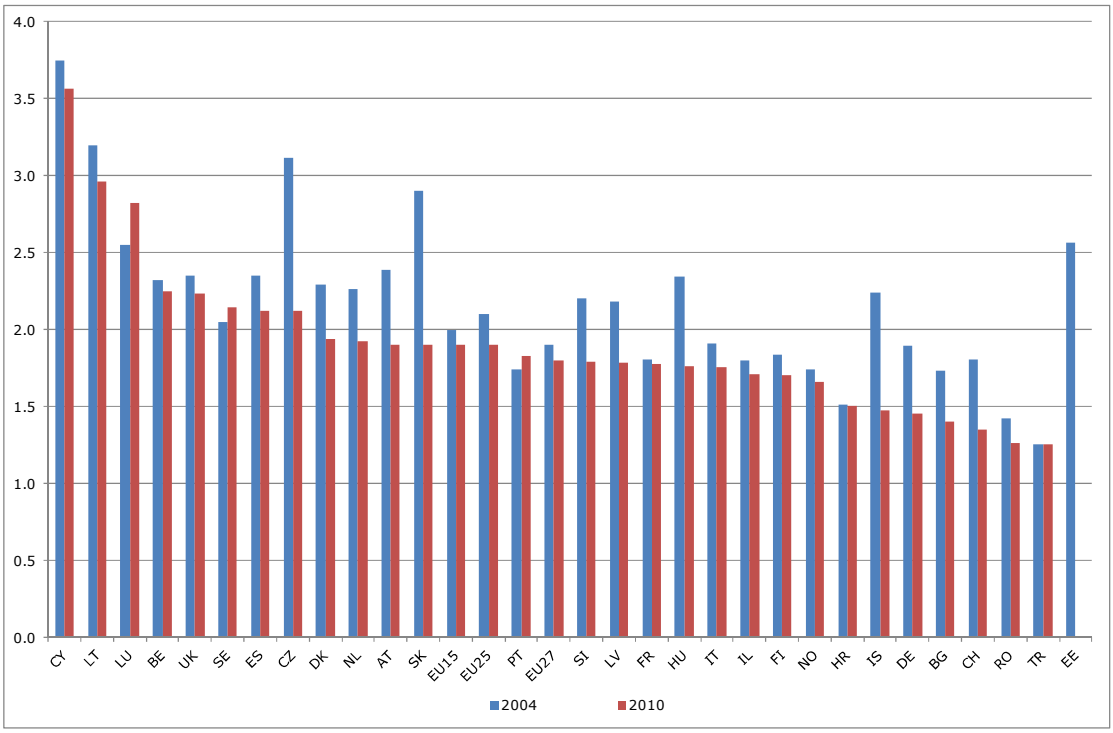
Source: our calculations based on She Figures 2012

9.4 Indicator 24: Glass Ceiling Index

Figure 60 shows the Glass Ceiling Index (GCI) in 2004 and 2010. The GCI measures the relative chance for women, as compared to men, of reaching a top position. The GCI compares the proportion of women in grade A positions (equivalent to Full Professors in most countries) to the proportion of women in academia (grade A, B, and C), indicating the opportunity, or lack of it, for women to move up the hierarchical ladder in their profession. A GCI of 1 indicates that there is no difference between women and men being promoted. A score of less than 1 means that women are over-represented at grade A level and a GCI score of more than 1 points towards a Glass Ceiling Effect, meaning that women are underrepresented in grade A positions. In other words, the interpretation of the GCI is that the higher the value, the thicker the Glass Ceiling and the more difficult it is for women to move into a higher position. It is important to note that differences between national grading systems may partially explain variations of the GCI between countries.

On average, throughout the EU27, the GCI equals 1.8 in 2010 (Figure 60) which means that slow progress has been made since 2004 when the index stood at 1.9. In 2010, in none of the countries is the GCI equal to or below 1. Its value ranges from 3.6 in Cyprus to 1.3 in Romania (and Turkey). Aside from Cyprus, the highest GCI was reported in Lithuania and Luxembourg. Between 2004 and 2010, the GCI has decreased in most countries. It remained stable in Sweden and France (also in Norway, Croatia and Turkey). However, the Glass Ceiling thickened over this period in Luxembourg and Portugal. Proactive policies need to be implemented in order to balance out the unequal situation that continues to prevail in the academic sector.

Figure 60: Glass Ceiling Index in 2004 and 2010



Source: our calculations based on WIS data

ANNEX 1 - METHODOLOGICAL CONSIDERATIONS WITH RESPECT TO DATA COLLECTION

This annex deals with problems encountered during data collection for the Researcher Indicators, both for updating the previous IISER indicators and for the collection of new information and indicators. As such, some of the shortcomings coincide with those addressed in the previous updating of the IISER indicators[50].

The problems encountered during the data collection to update existing indicators and to propose new ones can be grouped into three categories:

1. Missing data for some countries;
2. Comparability of data;
3. Complete lack of data.

In the next sections each of the three issues are further discussed.

A1.1 Missing data

Difficulties concerning missing data have been encountered during the data collection process for some of the IISER indicators to be updated.

For the Indicator 1 "Number of Researchers in the EU27", the research team had to consider the timing of data to collect. The indicator measures the number of researchers, both in FTE and in HC in each of the EU27 Member States as a total but also as a share of the active population. While for the majority of the countries FTE data were updated to 2011 and HC data were updated to 2010, for some of the countries the updating was less recent (as reported in the relative figures and tables).

A similar problem has been met when collecting data for Indicators 2 and 3. These indicators give information on the number of researchers working in different employment sectors (e.g., government, higher education, business enterprise, non-profit organizations), for each of the EU27 Member States plus some other non-EU27 countries. Again, for the majority of the EU27 countries it was possible to obtain complete and updated data up to 2010, but for some of them data were not updated. Moreover, some countries did not make separate data available for researchers employed in the business enterprise sector and those employed in non-profit organizations.

Considering Indicators 4 and 5 on researchers in the training phase (tertiary graduates academically oriented –ISCED 5A – and doctoral graduates – ISCED 6), problems were due to both a complete absence of updated data for some of the Member States and partly, to the availability of partial data for Italy. Actually, the Italian data seemed to have been updated and a strong reduction in the number of ISCED 5A graduates was shown. When investigating the reason for this reduction it appears that, in reality, the problem was that only partial data were made available. ISCED 5A data for both 2009 and 2010 covered only graduates ISCED 5A1. The number of graduates ISCED 5A2, necessary to have a correct figure for ISCED 5A, were completely absent. The problem was even more important considering the weight of Italian data on the EU27 total. Indeed, the mistake implied a strong reduction in the number of EU27 tertiary graduates academically oriented in 2009 and 2010. For this reason it has been decided to extrapolate the data for Italy for these two years. The method adopted has been

[50] Idea consult et al., 2010.

a linear interpolation in order to obtain data for 2009 and 2010, using the data available for 2008 and 2011.

The same problem was encountered for doctoral graduates (ISCED 6) and the same process was adopted. Indicator 6 on mobility of EU27 researchers in the training phase, inwards and outwards (or, which is the same, by country of origin and by country of destination), have been obtained by collecting data on the number of foreign doctoral candidates enrolled at universities in each EU27 country. Here again, for some of the countries data were not updated at 2010. Moreover, when calculating the number of foreign candidates as a share of total doctoral candidates in the country, further problems have arisen due to the fact that some countries do not make available separate data for students enrolled at ISCED 5 and 6 levels (doctoral candidates).

A1.2 Comparability of data

The first problem in terms of comparability of data refers to Indicators 4 and 5, i.e. the number of tertiary graduates (ISCED 5A) and of doctoral graduates. (ISCED 6).

In some of the EU27 countries, students are allowed to enrol contemporaneously in two or more degrees. This creates problems when the number of graduates has to be collected. For instance, using the Eurostat database, the number for tertiary graduates in Netherlands and in Germany is different depending on the query to the Eurostat database (specifically, data were different if the query was for [educ_grad4] or for [educ_grad5]).

Eurostat has been contacted for an explanation and it has been clarified that while "the number of graduates involves counting the number of persons that have graduated, the number of graduations is about counting the number of graduations obtained by those persons" So, in the cases where the same person has obtained more than one graduation we get: a number of graduates smaller than the number of graduations. This is very confusing, even after correcting the labelling for [educ_grad5] in the database, from "graduates" to "graduations"

There is also a second comparability problem with Indicators 6 to 10, i.e. on mobility of doctoral candidates within EU27 and outside EU27, on foreign doctoral candidates into EU27 and on EU27 researchers working outside EU.

The problem is due to the definition of 'foreigner' or 'non-citizen'. Each country adopts its own definition of foreign students or of foreign researchers, depending mainly on its immigration legislation. Some countries define a foreign student (or researcher) as a person who was not born in the country; other countries define a foreigner as someone who does not have permanent residence in the country under consideration. Some countries consider a foreign student (or researcher) to be a person who has taken her last degree in a country different from that in which she is currently enrolled or works. All these different definitions make it difficult to reach a full understanding about the mobility of students and researchers.

A1.3 Lack of data

To find data for Indicators 9 and 10 on the outflow of EU27 doctoral candidates and researchers has been particularly difficult given the lack of systematically collected data. For this reason, Indicator 9 on EU27 doctoral candidates obtaining the degree out of EU27 countries has been obtained using data from Open Doors, from NSF on the Survey of Earned Doctorate, and from the Australian government and the Japanese Ministry of Education. This has meant very partial

coverage, given that many other countries can be the potential destination for European doctoral candidates. As such, the information on mobility of EU27 doctoral candidates earning their degree outside EU27 is not complete.

For indicator 10, the number of EU researchers employed in countries other than the EU27, comparable data do not exist. We then provided some estimates based on available data. We used data on annual flows for citizens born in EU27 Member States who attained a research doctorate in US and had a definite commitment for research position in the US after graduation. When cumulating these flows under different scenarios about career length, we attained a reliable stock of EU27-born researchers in the US. Considering the number of EU-born HRST working in US we got a ratio that has been applied to the number of EU-born HRST working in Australia, Canada, New Zealand and Mexico in order to estimate the stock of EU27 born individuals working as researchers in these four countries too.

The Indicators 11 to 16 concern the mobility of researchers currently working in HEI (Report on survey of researchers in EU HEI) with respect to the duration of their move (longer or shorter than 3 months or permanent); the intersect oral mobility; the barriers to mobility and the non-mobility. Data on these aspects have not been systematically collected before, neither at single EU27 country levels nor with this level of detail, at the European level. A specific survey on all these aspects has therefore been carried out within the current MORE2 project[51].

The same survey has also collected data for Indicators 17 and 18 on collaboration of researchers with colleagues working in different countries and on the perception of virtual mobility as a substitute for short term mobility. This collected information is also new as no previous collection with this scope and level of detail has been completed before.

Finally, data on working conditions of researchers do not exist in a comparable form in available databases. Again, for the HEI researchers working in EU27, the survey carried out in this project[52] has made available the data used to obtain Indicator 22, which gives information on the different type of contract held by researchers in EU27 employed in HEI, and Indicator 23, on the share of EU27 researchers in HEI with different positions.

[51] See Idea Consult et al., 2013b.

[52] See Idea Consult et al., 2013b.

ANNEX 2 - STUDIES ON RESEARCHERS AND DOCTORAL CANDIDATES

In this annex, a review of some of the recent studies on European researchers and doctoral candidates' mobility is presented. The studies chosen are the most relevant to the current project[53] and, particularly, to this WP. The surveys and studies analysed show similar results and highlight the need to make researchers' careers more attractive through adoption of pan-European policies to increase recognition of the researcher's profession, increase work stability, augment research funding, implement salary increases, eliminate obstacles towards free circulation of brains and ideas. In order to realize the aforementioned goals, more coordination and collaboration among European stakeholders is needed.

A2.1 The CDH Survey

The Careers of Doctorate Holders (CDH) survey was launched in 2004 by the OECD, in coordination with the UNESCO Institute for Statistics and Eurostat. The main purpose was to address information gaps on this population. A tool kit was developed to obtain comparable data at international level on doctorate candidates; which included:

- Methodological guidelines;
- A model questionnaire;
- A set of reference output tables (key indicators).

After the first collection of data on a limited number of countries, the first large-scale data collection in 25 OECD countries was conducted in 2007. This collection provided a rich set of data but also highlighted a number of technical challenges which a further data collection in 2010 sought to address. Belgium, Bulgaria, Croatia, Denmark, Finland, Germany, Hungary, Iceland, Israel, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovenia, Spain, Sweden, Switzerland, Chinese Taipei, Turkey and the United States, collected information on the situation of doctorate holders as of 1 December 2009.

The report published in 2013 shows both some descriptive statistics as well as results from econometric studies based on the micro data collected through the survey. The main findings in the report54 are the following:

The number of doctorate holders is increasing in the OECD countries as well as in the workforce. Switzerland is the country with the highest share of doctoral graduates in the workforce. Unfortunately, there seems to be only a weak correlation between the number of doctoral holders in the labour force in a country and the R&D intensity.

The employment rate among doctorate holders is generally higher than among people with other relatively high qualifications. Working conditions are also generally satisfactory. Salary premiums seem to show a tendency to further increase in the future. Women have lower employment rates than their male colleagues and less opportunity for career growth (this result has also been confirmed by results published in She Figures 2012). The employment rate and working conditions are generally a little worse for the new doctorate holders (both male and female) with respect to their older colleagues. Earnings in agricultural sciences and humanities are below the overall median in most countries, whereas doctorate holders in medical and health are more highly paid. Doctorates in the business sector are typically better paid than in other sectors, but surprisingly,

[53] See Idea Consult et al., 2012.

[54] See OECD, 2013.

not in all countries. A wide range of monetary and non-pecuniary factors contribute to explain the reported attractiveness of research careers. Satisfaction levels on aspects other than pay are particularly high for individuals working in the higher education sector.

With regard to mobility, researchers show a strong variability across countries with respect to international mobility, but mobility is higher among doctorate holders not working in research than among those performing a research job. International mobility is a widespread and increasingly important phenomenon, although less common than might be expected. It has positive impacts on knowledge exchange and diffusion, but surprisingly it is not systematically associated with higher earnings. Individuals who have already experienced an episode of international mobility are more likely to intend to move abroad.

Intersectoral mobility from the higher education to the business sector is higher than the opposite only in a very few countries. Even when not in research, jobs are in most cases related to the subject of doctoral degrees and doctoral graduates are satisfied with their employment situation.

A2.2 The ERA Framework Public Consultation

The public consultation on the ERA framework, 'Areas of untapped potential for the development of the European research area', aimed at gathering, from stakeholders, views and evidence on the key obstacles which have to be tackled to achieve a well-functioning ERA. It was open from 13 September 2011 to 30 November 2011. All Member States are represented through at least one stakeholder contribution.

The main results are the following:

- Researchers are at the core of the European S&T system and respondents showed awareness of having to retrain more people into research careers and to strengthen the attractiveness of Europe as a place to work and study, especially for national and foreign top researchers. Provision of better skills during their training phase is also considered important.
- Many researchers affirmed that careers in the public sector are less attractive than those in the private sector, given the lack of career prospects and poorer working conditions, with respect to pecuniary (salary, funding) and non-pecuniary benefits (poor research facilities, little cooperation with industries, and so on). Lack of recognition of the research profession is lamented by researchers from both private and public sectors. Finally, the need for an increased gender equal opportunities policy is underlined.

The most important outcome with respect to mobility of researchers is that many barriers still prevent completely free circulation between countries and between sectors. The most frequently mentioned obstacles are:

- ✓ lack of open and transparent recruitment procedures, with protectionist/nepotistic behaviour in the recruitment process;
- ✓ lack of research funds portability;
- ✓ lack of qualification recognition;
- ✓ lack of sufficient information on social security and pension rights
- ✓ for inter-sectorial movements, it is more difficult to move from private to the public sectors.

The important message obtained from this survey is that almost all the researchers interviewed are in favour of more openness and increased "brain circulation". They also share the idea of a need for more cooperation and

collaboration among European stakeholders in order to secure the principles of the ERA project. "The principle of simplicity, low administrative burden, scientific autonomy, freedom of research, scientific integrity and ethical principles are considered as the most important principles in an ERA framework" (p. 11).

A2.3 The MAUNIMO (MApping UNIversity MObility)

The MAUNIMO survey was launched in 2010 when intra-EU mobility had long enjoyed high priority in the Bologna Process and in EU higher education policy. Ten years after the Bologna Process was been implemented, there was acute awareness by European governments that, while academic mobility in the European Higher Education Area (EHEA)[55] had probably not improved as anticipated, the data sources were not sufficient to assess this: the national data sets on student mobility, as a general rule, were incomplete and incompatible. The ability of the Bologna countries to aggregate them was limited. Even less was known about early researchers and staff mobility.

The study covers short-term mobility ('credit' or 'horizontal') and long-term ('programme' or 'vertical') mobility. A background study was carried out before the survey was launched and it addressed three main issues:

- ✓ how the mobility of students, early stage researchers, and staff in higher education is measured at international and European levels;
- ✓ the data gaps (i.e. concerning the category of mobile person, the volume of mobility, as well as its direction, duration and other matters);
- ✓ how mobility is monitored by a sample of HEIs in the light of the strategic interests of staff and students;
- ✓ how the monitoring might be improved.

The MAUNIMO consortium[56] thus developed an institutional self-assessment survey tool, the Mobility Mapping Tool (MMT) designed to be used across various European universities with diverse missions. The MMT was piloted at 34 universities in 21 countries. The results obtained by the respondents to the Survey on mobility can be summarised as follow:

- ✓ Although institutions may have strategies for mobility or internationalisation, many academic staff are not aware of their existence, or lack the necessary information to make a good use of them.
- ✓ Most MMT respondents, while acknowledging the potential social and cultural benefits of mobility for all members of their institution, believe that mobility is particularly important for the careers of doctoral candidates.
- ✓ Current actions at faculty and departmental level tend to focus on the mobility of Bachelor and Master's students. Doctoral candidates are also of considerable strategic interest but their mobility is often managed by separate structures within the institution. Potential links between the mobility of Bachelor and Master's students, and subsequent doctoral candidate mobility are not sufficiently coordinated in strategic planning.
- ✓ MMT respondents reported that the mobility of administrative staff at their institution was not as highly prioritised as that of other potentially mobile groups.

[55] EHEA is made up by: the EU27 Member States, EEA countries, the Candidate countries, the Russian Federation among others. Totally, countries adhering to EHEA are 47 countries. The last country entering the Bologna process was Kazakhstan, in 2010

[56] See EUA, 2012 for the members of the consortium.

- ✓ Institutions seem to crave good practice in enhancing the quality of mobility, especially as regards innovative assessment methods and the data collection that underpins it.
- ✓ Many institutions were surprised to find that, despite widespread usage of the European Credit Transfer and Accumulation System (ECTS) and the Diploma Supplement, awareness of and exploitation of these instruments was still not as extensive as anticipated.
- ✓ In general, institutions are interested in more coherent, cross-institutional approaches to mapping mobility and data collection, and the MMT has proven to be a possible tool to support this process. Current institutional mobility-data collection is conditioned by funding programmes, and in particular by the ERASMUS Programme. However, there is little information on free movers, whether students and staff. Data collection is also often decentralised and fragmented.

The study concludes by offering several suggestions:

- ✓ Uphold and enhance diverse institutional mobility goals and approaches;
- ✓ More coordination in the process of data collection is needed as well as broader framework;
- ✓ Implement policies to reduce the complexity of data collection, transfer and protection;
- ✓ The EU should play a stronger role in developing programme synergies and inter-service cooperation;
- ✓ Make the social dimension of mobility a reality;
- ✓ Recommend countries to put more effort in solving the persistent problem of recognition;
- ✓ Make the case for mobility.

The study ends with unanswered questions, among which the most relevant are:

"How much mobility do we actually 'need' and should mobility be voluntary or a compulsory element of academic studies, regulated by institutions and/or national authorities"[57].

The answers to these questions will require still lots of study to better know the current situation in Europe.

A2.4 The Erawatch study

The survey on mobility of researchers by the Institute for Prospective Technology Studies (IPTS) and the EU's Joint Research Centre, was launched in the spring of 2011 and the results published at the end of the year in the report "Tackling barriers and bottlenecks to making research careers more attractive and promoting mobility"[58].

Respondents have reported various rigidities. In the Country Reports it has been highlighted the worsening working conditions in the research profession are linked to the increasing share of short-term contracts and the difficult, if not virtually impossible, access to university careers for young scientists. These elements represent handicaps in the recruitment of well qualified young researchers, both nationals and foreigners. Rewarding productivity and quality in researcher salary schemes has the potential to improve performance and could lead to excellence in

[57] See EUA, 2012, p. 57.

[58] See Fernàndez-Zubieta, 2011.

research. It also could make researchers' careers more attractive, but survey results show that rewarding productivity and quality is not common in EU Member States. Productivity and quality tend to be rewarded through career development 'promotion' rather than salary schemes.

As in the studies reviewed in previous sections, elements of concern have arisen with respect to the provision of social security benefits (sickness, parental, unemployment and pension). Evidence of differences across countries with respect to the type of benefit and the type of contract (open-ended, fixed-term 'institutional', or fixed-term project-based) has emerged in the survey. For example, in the specific case of pensions, publicly-funded research institutions do not tend to contribute to researchers' supplementary pension schemes.

Gender is an important matter. Women are still underrepresented in science and therefore constitute one of the main sources of untapped research potential in Europe. More involvement of women in science will contribute to socioeconomic growth in Europe. Thus, an adequate representation of women could be the requirement for Member States to respect an adequate gender balance in selection and evaluation committees.

A variety of policies and instruments to increase the mobility of researchers have been adopted by governments:

- ✓ Most countries have implemented policy initiatives (such as the use of different taxation exemptions) to attract foreign researchers.
- ✓ Some countries concentrate more on bilateral research collaboration and the return of national researchers working abroad (e.g. Bulgaria, Slovakia, Czech Republic or Poland).

The rationale behind the choice of implementing policies to increase researchers' mobility seems to be different for the various countries analysed. Member States with strong research systems regards the inclusion of foreign researchers as a point of strength in improving research quality. They are assumed to bring new methods and new ideas for the research profession to investigate. This is particularly true for countries such as Austria, Germany and Ireland.

The return of nationals abroad is the main rationale behind the need to adopt mobility "friendly" policies for researchers. This strategy is adopted by countries that suffer from brain drain, like Italy, and is mainly driven by two reasons: large number of nationals abroad due to the lack of enough researcher positions and by countries whose research system is still too unattractive for foreigners, like Poland, Latvia and Romania.

From the survey, the following barriers to mobility have emerged:

a) Lack of transparency in advertising positions;
b) Language requirements[59].
c) "The issue of academic inbreeding in public research institutions (i.e. informal practices which end up favouring incumbent candidates in selection procedures) is difficult to understand and even more difficult to tackle from a regulatory perspective"[60].

[59] The requirement of speaking the national language becomes a disincentive when trying to attract foreign researchers. Nowadays, scientific publications are mainly produced in English. This language is also perceived to be "the international scientific language" by most researchers. That said, the requirement of national language could be softened by non-English speaking countries, in order to partly eliminate language barriers.

[60] This does not occur very frequently in Austria, Finland, Ireland, Luxembourg, the Netherlands, Sweden and the United Kingdom. It is a common practice in Greece, Hungary, Italy, Latvia, Malta, Romania, Slovenia and Spain. See Fernàndes-Zubilieta, 2011, p. 10.

d) The problem of the equivalence of foreign ranks has not yet been solved.
e) Difficulties in recognition of foreign degrees are still at stake. Some countries have centrally - coordinated accreditation procedures to establish the equivalence of foreign degrees or academic ranks. Others do not.
f) Finally, there is the issue of portability of grants. If Europe is to guarantee the free circulation of knowledge, researchers should be able to move freely in search for jobs and funding. They should also be able – in principle – to take their funding to any other European Member State.

ANNEX 3 – THE STOCK OF NON-EU RESEARCHERS CURRENTLY WORKING IN THE EU

In order for the EU to grow and remain competitive, it needs to attract talented non-EU students and researchers. Moving to Europe temporarily is an opportunity embraced by over 200,000 students and researchers from outside the EU every year.[61]

Indicator 8 of this report provides information on the inflows of doctoral candidates into the EU27. In this annex the focus is not on doctoral candidates alone but on researchers in general.

This annex consists of three sections. In the first section an overview of foreign researchers currently working in the EU is provided. This concerns both EU as well as non-EU researchers working in an EU country which is not the country where they resided at 18. In the second section, the limited data which is available on non-EU researchers currently working in the EU is provided. As there is only limited data available we provide some estimates of non-EU researchers currently working in the EU in the third section. These estimates are based on data of the MORE2 HEI survey[62].

A3.1 Foreign (EU as well as non-EU) researchers currently working in the EU

Franzoni et al. (2012)[63] performed a systematic study of the mobility of scientists engaged in research. This GlobSci Survey was administered from February until June 2011 and covers 17,182 scientists[64], four fields of research (biology, chemistry, earth and environmental sciences and materials) in 16 countries.

Results indicate that Switzerland has the highest share of foreign scientists active as researchers (56.7%), followed by Sweden (37.6%), the UK (32.9%), the Netherlands (27.7%), Germany (23.2%), Denmark (21.8%), Belgium (18.2%) and France (17.3%). Both Italy and Spain have a low share of foreign researchers; respectively 3% and 7.3% (see Table 33).

The countries which supply 10% or more of foreign scientists in research are mainly EU countries; neighbouring countries such as Germany, France and Italy are often countries of origin of immigration. Exceptions are Spain which has 12.6% of researchers originating from Argentina and Sweden which has 10.2% of researchers originating from the Russian Federation. Another observation is that the foreign presence of researchers in Germany is quite diversified as none of the countries supplied more than 10% of the foreign workforce.

61 http://europa.eu/rapid/press-release_IP-13-275_en.htm

62 See Idea Consult et al, 2013b.

63 Franzoni, C., Scellato, G. and P. Stephan (2012). Foreign born scientists: Mobility patterns for sixteen countries. NBER working paper series 12-5-1.

64 For whom country of origin and country of residence in 2011 were known.

Table 33: Share of foreign researchers in 10 EU countries

Country of work/study in 2011	Share outside country at 18	Countries supplying 10% or more of foreign workforce
Belgium	18.2%	Germany (15.2%), France (15.2%), Italy (13.0%)
Denmark	21.8%	Germany (24.4%)
France	17.3%	Italy (13.8%)
Germany	23.2%	none
Italy	3.0%	France (13.0%), Germany (11.1%) and Spain (11.1%)
The Netherlands	27.7%	Germany (14.6%), Italy (12.5%)
Spain	7.3%	Argentina (12.6%), France (10.3%) and Italy (10.3%)
Sweden	37.6%	Germany (11.9%), Russian F. (10.2%)
Switzerland	56.7%	Germany (36.9%)
UK	32.9%	Germany (15.2%), Italy (10.4%)

Source: Franzoni et al. (2012): The GlobSci Survey

Some absolute figures on the number of foreigners in EU countries show that about 33,000 international researchers are active in German higher education institutions, of which about 2,600 are professors.[65]

In the next section the focus is narrower, as only non-EU researchers currently working in the EU are discussed.

A3.2 Data on non-EU researchers currently working in the EU

Non-EU researchers (and students) by country

According to Eurostat, in 2011, around 7,000 non-EU nationals arrived for purposes of research[66] in the 24 EU Member States covered by the data; mostly in France (2,075), the Netherlands (1,616), Sweden (817), Finland (510) and Spain (447). This information only provides us a snapshot of inflows of non-EU researchers in 2011 but it confirms that countries like France, the Netherlands, Sweden, Finland and Spain are important destination countries for non-EU researchers. Data on the United Kingdom and Denmark are missing.[67]

Considering the mobility patterns of the 220,000 students and researchers originating from outside the EU in 2011, the countries which received the highest number of inward student mobility were France (64,794), Spain (35,037), Italy (30,260), Germany (27,568) and the Netherlands (10,701)[68]. Results from CDH 2009 data (OECD, 2012) also indicate that France, Germany and the United Kingdom appear among the most popular destinations for EU mobility.

65 German Funding Programmes for Scientists and Researchers: Funding Opportunities for International PhD Students, Postdocs, Junior and Senior Researchers.

66 Purpose of research in general, not HEI specific.

67 The Eurostat data does not include Denmark and the UK as these countries are not bounded by the 'Researchers Directive'.http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:289:0015:0022:EN:PDF

68 http://europa.eu/rapid/press-release_IP-13-275_en.htm.

Non-EU researchers by career stage

The total number of *doctoral candidates* in 2004 in the EU, according to EUROSTAT data, is approximately 433,000. About 73,000 of these doctoral candidates are from outside the EU. The share of non-EU doctoral candidates as a percentage of all doctoral candidates in the EU is thus 16.9%.[69] In 2010, there were around 735,000 doctoral candidates in the EU, of which about 20% are from outside the EU.[70] For more information on non-EU doctoral candidates please see Indicator 8 in section 6.3.

Results of the survey of young researchers in *life sciences* in Europe[71] indicate that in 2003 there are about 37,000 doctoral candidates (R1 researchers) in the EU25. About 6,000 of these doctoral candidates are from third countries (16%). This share of 16% non-EU doctoral candidates for life sciences is very similar to the overall share of non-EU doctoral candidates (16.9% in 2004). The same survey indicates that there are about 19,000 post doctorates (R2 researchers) in life sciences, of which 4,800 (24%) originate from third countries.

Focusing on the *doctorate holders* (R2, R3 and R4 researchers), Table 34 gives an overview of the share of non-EU doctorate holders (relative to the total amount of doctoral holders per EU country) per EU country (CDH 2009 data)[72]. The highest share of foreign doctorate holders is in Poland (14%), followed by Sweden (7%), Germany (3%), Finland (3%), Portugal (3%) and Denmark (2%). EU12 countries mainly have a share of non-EU doctorate holders of 1% or lower (exception Poland).

Table 34: Share of Non-EU doctorate holders by country (%)

Country	Non EU researchers	
	2006	2009
Bulgaria	0.00	0.33
Denmark	n.a.	2.42
Germany	n.a.	3.36
Estonia	0.60	n.a.
Cyprus	0.93	n.a.
Latvia	0.53	n.a.
Lithuania	0.33	0.31
Hungary	n.a.	1.14
Malta	n.a.	0.47
Poland	n.a.	14.28
Portugal	2.35	2.52
Finland	n.a.	2.78
Sweden	6.75	n.a.

Source: CDH 2009 survey (Eurostat)

69 http://ipts.jrc.ec.europa.eu/docs/iiser_intra-eu.pdf: Based on EUROSTAT data for 16 EU countries.

70 The Researchers report (2013), based on Eurostat data. This breakdown of the doctoral candidates in EU27 by citizenship is based on the 535,000 doctoral candidates for which information on citizenship was available. Germany estimates its number of doctoral candidates at 200,400 for 2011. This number was integrated in the 2010 total. But this information was not included in this figure as for no breakdown by country of citizenship was possible.

71 http://ipts.jrc.ec.europa.eu/docs/iiser_intra-eu.pdf

72 CDH survey, Auriol L., B. Felix, M. Schaaper (2010) Mapping careers and mobility of doctorate holders: draft guidelines, model questionnaire and indicators – second edition – the OECD/UNESCO institute for statistics/Eurostat careers of doctorate holders project, STI working paper 2010/1.

A3.3 Estimates of non-EU researchers currently working in the EU

As non-EU researchers are important for the EU, this section provides an overview of some estimated figures on non-EU researchers currently working in the EU by country, field of science and career stage. The HEI survey[73] will be the main source of information for providing some estimated figures.

Although the survey on HEIs is representative, it has not been designed to make estimations about researchers according to their citizenship, and it is thus not easy to generalize about any result with accuracy, as the necessary auxiliary information is not available. In many strata the sample includes only some units with the non-EU feature (i.e. non-EU researchers). Before any generalizations can be made, some benchmark with official data (which is problematic) is necessary.

Despite all these limitations, it is possible, by adopting an 'empirical' method, to provide some estimation of the shares of extra-EU researchers currently working in Europe (in HEI), based on the HEI survey sample.[74]

The HEI sample reached 495 researchers with non-EU citizenship, through the re-proportioning of the ratio Non-EU researchers/Total researchers within the sample in each country.

The total number of non-EU researchers adopting re-proportioning within the sample is equal to 69,856 in EU27. This is 5.6% of the total amount of researchers working in the EU.

Non-EU researchers by country

Table 35 shows an estimation of the distribution of non-EU researchers working in the EU by country.[75] Non-EU researchers in the EU are concentrated in a small group of countries. In Germany and UK we find more than 50% of non-EU researchers.

[73] See Idea Consult et al, 2013b

[74] The provided estimates are purely empirically based.

[75] Country refers to the panel country of the respondent which was identified during the data collection process of the survey on HEI.

Table 35: Distribution of non-EU researchers by country

Country	Non EU researchers	
	Number	Percentage
Austria	1,108	1.6%
Belgium	1,834	2.6%
Bulgaria	0	0.0%
Cyprus	5	0.0%
Czech Republic	391	0.6%
Denmark	3,129	4.5%
Estonia	87	0.1%
Finland	2,131	3.1%
France	6,104	8.7%
Germany	16,395	23.5%
Greece	76	0.1%
Hungary	298	0.4%
Ireland	966	1.4%
Italy	478	0.7%
Latvia	148	0.2%
Lithuania	86	0.1%
Luxembourg	75	0.1%
Malta	3	0.0%
Netherlands	4,053	5.8%
Poland	546	0.8%
Portugal	1,095	1.6%
Romania	181	0.3%
Slovakia	221	0.3%
Slovenia	72	0.1%
Spain	2,531	3.6%
Sweden	6,243	8.9%
United Kingdom	21,599	30.9%
Total	***69,856***	***5.6%***

Source: Estimations based on the MORE2 EU Higher Education Survey (2012)

Table 36 shows the distribution of non-EU researchers in Europe by citizenship (top 20). Non-EU researchers in the EU are, again, highly concentrated in a small number of countries; 78.8% of all the non-EU researchers come from 20 countries. China (14%), India (12%) and the US (11%) take up the largest share.

Table 36: Non-EU researchers by country of citizenship, top twenty

Country of citizenship	Non EU researchers	
	Number	Percentage
China	67	13.5%
India	59	11.9%
United States	52	10.5%
Russia	31	6.3%
Canada	24	4.8%
Pakistan	24	4.8%
Iran	21	4.2%
Turkey	14	2.8%
Bangladesh	10	2.0%
Norway	10	2.0%
Switzerland	10	2.0%
Australia	9	1.8%
Brazil	9	1.8%
Japan	8	1.6%
Ukraine	8	1.6%
Vietnam	8	1.6%
Algeria	7	1.4%
Colombia	7	1.4%
Cameroon	6	1.2%
Nigeria	6	1.2%

Source: Estimations based on the MORE2 EU Higher Education Survey (2012)

Non-EU researchers in the EU by field of science

The shares of non-EU researchers in the EU27 by field of science are shown in Table 37. The largest share of non-EU researchers in the EU (62%) is working in natural sciences followed by 21% in social sciences.

Table 37: Non-EU researchers in the EU27 by field of science

Natural		Health		Social		Total	
8.80%	n = 43,270	3.70%	n = 11,126	3.40%	n = 15,460	5.60%	n = 69,856

Source: Estimations based on the MORE2 EU Higher Education Survey (2012)

Non-EU researchers in the EU by career stage

An estimation of the shares of non-EU researchers in the EU27 by career stage based on the HEI survey are shown in Table 38. About 46% of the non-EU researchers in the EU are first stage researchers (R1). R2 and R3 researchers account for a share of 25% and 18% respectively. Foreign R4 researchers are least represented in the EU (10%).

Table 38: Non-EU researchers in the EU27 by career stage

R1		R2		R3		R4		Total
46.10%	n = 32,176	25.30%	n = 17,640	18.40%	n = 12,842	10.30%	n = 7,197	n = 69,856

Source: Estimations based on the MORE2 EU Higher Education Survey (2012)

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