Stock, Career and Mobility of Researchers in the EU

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Philippe Moguérou, Maria Paola Di Pietrogiacomo

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Preface

This report is part of the FP6 Specific Support Action “Integrated Information System on European Researchers” (IISER) project which aimed at setting up a sustainable European-wide system of indicators to provide a dynamic overview of researchers' stock, flow, career and mobility. The project was constituted of two main phases: IISER1 (December 2004-April 2006) and IISER2 (May 2006-December 2007).

The project in its first phase 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. On the basis of the accumulated knowledge, DG Research defined a list of indicators on researchers’ career and mobility to be produced by JRC-IPTS during the second phase of the IISER project (May 2006-December 2007). They form the basis of this report.
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1 Executive summary

The stock of researchers in the EU

Researchers are defined according to the Frascati Manual 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'. This definition is applied in R&D surveys that are the source for Eurostat and the Organisation for Economic and Co-operation Development (OECD) research and development (R&D) statistics.

In 2005, there were 1.3 million full-time equivalent (FTE) researchers in the EU-27, 1.4 million in the US, 704 000 in Japan and 1.1 million in China (3.9 million in total in the OECD region). Demand for researchers is lower in the EU-27 (0.56% of labour force) than in the US (0.93%) and Japan (1.06%). The corresponding share is 0.70% on average in the OECD region and 0.15% in China.

The number of FTE researchers increased from 964 000 in 1995 to 1.3 million in 2005 in the EU-27 (+3.0% per year). Over the same period, the increases were 3.0% per year in the US, 0.5% in Japan, 7.9% in China, and 3.3% on average in the OECD region.

The share of business researchers in the total number of researchers differs widely between the EU-27 (48%) and the US (79%), Japan and China being in-between with 68% and 62% respectively. Business researchers accounted for 0.27% of labour force in the EU-27 in 2005, 0.74% in the US, 0.72% in Japan and 0.09% in China (0.70% on average in the OECD). The number of business researchers increased from 436 000 to 629 000 over 1998-2005 in the EU-27 (+3.7% per year on average). The corresponding growths were 3.4% per year in the US, 2.3% in Japan and 13.7% in China (OECD average: 3.7%).

The supply of higher education graduates and postdoctorates in the EU

In order to estimate the potential evolution of human resources in science and technology in Europe, the evolution of the number of higher education degrees with academic orientation and the number of doctoral degrees is analysed over the period 1998 to 2005.

In 2005, 3 million tertiary degrees with academic orientation were granted in the EU-27, against 2.1 million in the US and 640 000 in Japan. From 1998 to 2005, a regular increase was observed: the number of degrees increased by 6.7% per year on average in the EU-27, by 3.3% in the US and by 1.3% in Japan.

In the EU-27, the number of degrees in science, mathematics and computing increased by 6.8% per year on average between 1998 and 2005 (3.6% in the US and 1.8% in Japan), while in engineering, manufacturing and construction, the increase was less pronounced, 4.5% per year (1.8% in the US and 0.3% in Japan). All EU countries show a positive growth in the number of degrees in science, mathematics and computing, while in engineering, manufacturing and construction, five EU countries experienced a decrease.
In 2005, some 100,000 doctoral degrees were conferred in the EU-27, against 53,000 in the US and 15,000 in Japan. From 1998 to 2005, the number of doctoral degrees increased respectively by 4.4% per year on average in the EU-27, by 2% in the US and by 5.7% in Japan.

In the EU-27, the number of doctoral degrees in science, mathematics and computing increased by 2.7% per year on average from 1998 to 2005, while in engineering, manufacturing and construction, it increased by 3.8% per year. Four EU countries show a decrease in science, mathematics and computing, and three EU countries in engineering, manufacturing and construction.

International mobility of researchers within, into and out of the EU

In 2005 in the EU (based on 21 EU countries having reported data to Eurostat), of the 487,000 doctoral candidates, 28,000 held the nationality of another EU Member State, accounting for 5.8%, and 69,000 were citizens of third countries, accounting for 14.1%.

The UK had the highest number of doctoral candidates of EU origin, some 11,500, in 2005. It is followed by France (5,400) and Spain (3,100). No other single country had more than 2,000 doctoral candidates holding the nationality of another Member State. As a share of the total number of doctoral candidates of the reporting country, the UK, Austria and Belgium were the 3 top countries, having 12.5%, 12.5% and 12.1% respectively of their doctoral candidates with citizenship of another EU country. In 13 countries out of 21, foreign EU candidates accounted for less than 5% of enrolments at doctoral level.

The UK was the most important intra-EU net gainer, in absolute and relative terms, of the intra-EU exchanges of doctoral candidates, with a intra-EU net gain of 5,300 doctoral candidates, accounting for 5.8% of the total number of doctoral candidates in the UK. The other countries with a positive intra-EU net gain are France, Spain, Austria, Sweden, the Czech Republic, Finland and Belgium.

5.3% of doctoral candidates in the EU were from Asia, the Middle East and Oceania, 3.7% from Africa, 3.1% from South and central America, 1.1% from other European countries (outside the EU-27) and 0.9% from North America. The share of North American citizens is below 1% in all of the 21 reporting Member States except in the UK (3.7%).

China ranks top for the number of its citizens' doctoral candidates in the EU, about 5,200, accounting for 7.5% of the total number of doctoral candidates from third countries in the EU. Mexico and Morocco rank second and third. The US ranks fourth, with 3,000 individuals, accounting for about 4.4% of doctoral candidates from third countries (or 0.62% of the total number of doctoral candidates) in the EU. Of these US citizens, 2,400 are located in the UK.

The three major EU receiving countries (out of 21) of doctoral candidates from third countries are the UK, France and Spain, with 24,100, 23,000 and 11,300 respectively. All three together received 58,400 doctoral candidates from third countries, accounting for 84.8% of the EU total from third countries. The remaining countries each received less than 2,000 individuals. As percentage of the total number of doctoral candidates in the reporting country, France, the UK, Belgium and Spain received the highest share of doctoral candidates from third
countries, 27.9%, 26.3%, 18.7% and 14.8% respectively. All the other countries are below 10%.

Using 2 pilot ad hoc surveys commissioned by JRC-IPTS, we have estimated that, in the EU-27, 9% of doctoral candidates in the life sciences, 8% in engineering and 7% in the social sciences, are EU nationals who work in another EU country, and that, 16% of doctoral candidates in the life sciences, 23% in engineering and 18% in the social sciences are from third countries. With the same 2 surveys, we have found that 18% of postdoctoral researchers in the life sciences, 11% in engineering and 9% in the social sciences are from other EU countries, and that 24% in the life sciences, 18% in engineering and 13% in the social sciences are from third countries.

Based on an analysis of the citizenship of ‘Science, Engineering and Technology (SET) professionals’ in six European countries with national Labour Force Surveys, it has been found that the proportion of non-nationals ‘SET professionals’ is 0.1% in Poland, 4.5% in the Netherlands, 4.8% in France, 6.2% in Germany, 7% in Norway and 10.2% in the UK. The proportion of non-nationals with EU-25 citizenships is 0.1% in Poland, 1.2% in The Netherlands, 2.7% in France, 3.3% in Germany, 3.6% in the UK and 4.6% in Norway.

In the 14 EU Member States where data are available and reliable on Human Resources in Science and Technology Core (HRSTC), on average, in 2006, 4.4% of HRSTC were non-nationals: 2.4% were non-nationals having EU-27 citizenship and 2% were non-nationals having citizenship outside EU-27. The shares of foreign-born HRSTC are somewhat higher. On average, 9.1% of HRSTC were foreign-born in 2006: 3.2% were born in another EU Member State and 5.9% in a country outside the EU.

In 2005, 43 300 doctorates were granted by US universities. Of the 2005 doctorate recipients with known citizenships, about 35% were non-US citizens. The top countries in terms of the number of doctorates conferred to its citizens are China (which accounts for 9.4% of all doctorates conferred by US universities), South Korea (3.8%), India (3.1), Taiwan (1.8%) and Canada (1.4%).

The 8 top EU countries are as follows: Germany (11th), Romania (12th), Italy (14th), the UK (15th), France (17th), Spain (20th), Greece (23rd) and Bulgaria (26th). These 8 EU countries account for 3.1% of the total number of doctorates conferred by US institutions (or 9% of the number of non-US citizens earning doctorates). On average, US universities confer about 1.8 doctorates to citizens of these 8 countries for every 100 granted at home. This ratio ranges from 17.4% for Bulgaria to 1% for Germany.

In S&E fields, some 26 300 doctorates were conferred by US universities in 2004. Of these, 40% were conferred to non-US citizens (among those with known citizenships), 26.9% to Asians and 6.6% to Europeans (all Europe). Citizens from the UK, Germany and France account for 1.5% (about 400 individuals) while all the other European countries account for 5.1% (about 1 300 individuals).

In 2005/06, nearly 97 000 foreign scholars were working in the US. Asia is the leading place of origin for foreign scholars in the US with some 48 000 individuals. Nearly 25 000 scholars hosted in the US come from the EU-27. They account for about 29% of the total number of foreign scholars in the US.
In 2005/06, the top countries of origin of foreign scholars in the US are China (with some 19,000 individuals), Korea (8,900), India (8,800) and Japan (5,600). Among the top 10 countries of origin of foreign scholars in the US, there are four EU countries: Germany in fifth place (5,100), France seventh (3,400), the UK eighth (3,300) and Italy ninth (3,000).

Compared to the size of the local academic workforce, 2.3 scholars hold position in the US per 100 working at home on average for the EU. This ratio is the highest for Cyprus (7.4), Ireland (4.7), the Netherlands (4.7), Romania (4.6) and Italy (4.0).
2 The stock of researchers in the European Union

In this section we will analyse the evolution of the number of researchers in the European Union\(^1\) over the last decade. Section 2.1 deals with concepts and definition. Section 2.2 presents some elements of international comparisons. Section 2.3 studies the evolution of the number of researchers in the EU. Section 2.4 carries out a short- and medium-term forecasting exercise of the number of researchers.

2.1 Concepts and definitions

Defining and appraising 'scientists' is not a simple matter. Many different terms are used to qualify 'scientists' (in a broad sense): qualified personnel, highly skilled workers, human resources in science and technology, brains, scientists, engineers, R&D personnel, and researchers, among others.

Identifying skills is a traditional but complex solution to specifying and classifying jobs. The term skill refers to the general capacities, the abilities to apply knowledge to perform and complete a set of tasks, and to solve problems. They include physical abilities (e.g. dexterity, strength, speed), cognitive skills (e.g. reasoning, logical thinking, perception, numerical and verbal abilities) and interpersonal skills (e.g. social communication and interactions, leadership).

In empirical work, researchers frequently use proxies based on education and occupation. Education is usually measured by years of schooling or final degree obtained, but it is quite specific to individual educational systems. Occupations provide more information on the skills required of workers, but they vary across countries and may be ambiguous. Therefore, one possible solution is to use international standard classifications.

For education, the International Standard Classification of Education (ISCED97) is a framework for the compilation and presentation of national and international education statistics and indicators, which is maintained by the UNESCO Institute for Statistics\(^2\). It has been designed to serve as an instrument suitable for assembling, compiling and presenting comparable indicators and statistics of education both within individual countries and internationally. It is a classification both of levels of education and of fields of study. The term 'qualified' refers to formal qualifications.

For occupations, the corresponding classification is the International Standard Classification of Occupations (ISCO), for which the International Labour Organisation is responsible\(^3\). It is a tool for organising jobs into a clearly defined set of groups according to the tasks and duties

\(^{1}\) Some data refer to the EU-25 and some to the EU-27. It has not been possible to fully harmonise the geographical coverage as some data were not available or incomplete when the calculations were made, and recent updates have introduced inconsistencies.

\(^{2}\) See http://www.uis.unesco.org/ev.php?ID=3813_201&ID2=DO_TOPIC

undertaken in the job. The current (and third) version of the International Standard Classification of Occupations, ISCO-88, was adopted by the 14th International Conference of Labour Statisticians in 1987. ISCO-88 is currently in the process of being updated to take into account developments in the economies of countries worldwide. The updated version will be ready in 2008. ISCO-88 groups jobs together in occupations and more aggregate groups mainly on the basis of the similarity of skills required to fulfil the tasks and duties of the jobs. Two dimensions of the skill concept are used in the definition of ISCO-88 groups:

- skill level, which is a function of the range and complexity of the tasks involved;
- skill specialisation, which reflects the type of knowledge applied, the tools and equipment used, the materials worked on, or with, and the nature of the goods and services produced.

Unfortunately, there is no agreement on a definition of highly skilled/qualified workers at international level. However, an international framework, known as the Canberra Manual, has been jointly developed by Eurostat and OECD to measure the Human Resources devoted to Science and Technology (HRST). The Canberra Manual proposed guidelines for the measurement of human resources devoted to science and technology (S&T). It has been prepared by the OECD Group of National Experts in Science and Technology Indicators.

There is also a document stipulating the methodology involved in 'measuring' R&D personnel and researchers, known as the Frascati Manual. The Frascati Manual proposed standard practice for surveys on research and experimental development. The Frascati Manual has become the internationally recognised methodology for collecting and using R&D statistics.

### 2.1.1 HRST

The Canberra Manual proposes a definition of HRST as persons who either have higher education, or persons who are employed in positions that normally require such education. HRST are people who fulfil one of the following conditions:

a) successfully completed third-level education in an S&T field of study (HRSTE);

b) not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required (HRSTO).

Under this definition, people can be HRST on the basis of either a renewable event (occupation) or a non-renewable one (education). Once people have successfully completed third-level education they are HRST for life, whatever their occupation. The situation is different for people who are HRST on the basis of their current occupation, without being

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6 Other international manuals exist, such as the Oslo Manual (Guidelines for collecting and interpreting innovation data).
formally qualified. Their status as HRST ends as soon as they change to an occupation outside S&T, retire, or become unemployed or inactive.

In this definition, S&T is defined in 7 broad fields of study: natural sciences, engineering and technology, medical sciences, agricultural sciences, social sciences, humanities, and other fields. Education at the third level covers studies leading to a first or higher university degree and also other studies at post-secondary level leading to awards not fully equivalent to a first university degree. The International Standard Classification of Education (ISCED) is used.

Occupations are defined in terms of jobs. Only current employment is considered. Employment refers to any kind of work, even that lasting as little as one hour, for pay (paid employment) or profit (self-employment) during the reference period (usually one week). S&T occupations are defined using the following ISCO-88 categories:

- 122: production and operations department managers
- 123: other department managers
- 131: general managers
- 21: physical, mathematical and engineering science professionals
- 22: life science and health professionals
- 23: teaching professionals
- 24: other professionals
- 31: physical and engineering science associate professionals
- 32: life science and health associate professionals
- 33: teaching associate professionals
- 34: other associate professionals

The advantage of using a double educational/occupational classification is that it takes into account both the supply side of HRST (in terms of qualification) and the demand side (in terms of occupation), but it does have the following drawbacks.

- It does not allow for homogeneous measurement because the two classifications are based on different premises.
- It is too broad to meet specific analytical needs. Notably, it may be criticised for being 'too wide' insofar as it includes many persons who are not involved in R&D in their professional activities.

Therefore, subsets within this broad category have been defined, as set out below:

- HRST core (HRSTC): HRST population with both tertiary-level education and an S&T occupation;
- scientists and engineers: generally defined as ISCO categories 21 (physical, mathematical and engineering science professionals) and 22 (life science and health professionals);

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• IT labour force: ISCO categories 213 (computing professionals), 1236 (computing services department managers) and 312 (computer associate professionals).

2.1.2 R&D personnel and researchers

ISCO does not have a code to define researcher. Consequently, we do not have a clear-cut definition that enables us to select and distinguish them from other types of skilled labour. The *Frascati Manual* proposes the following definitions of R&D, R&D personnel and researchers:

- research and experimental development: 'research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.' (p. 31);
- R&D personnel: 'all persons employed directly on R&D should be counted, as well as those providing direct services such as R&D managers, administrators, and clerical staff.' (p. 92);
- researchers: 'researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.' (p.93);

Researchers are classified in ISCO-88 Major Group 2, 'professionals', and in 'research and development department managers' (ISCO-88, 1237). The *Frascati Manual* recommends that, by convention, members of the armed forces with similar skills who perform R&D should also be included. Postgraduate students at doctoral level engaged in R&D should be considered as researchers.

According to the *Frascati Manual*, R&D surveys are the most appropriate instrument for collecting R&D personnel data. 'Population censuses, labour force surveys or population registers are useful complementary data sources but cannot be used systematically to obtain R&D personnel data.' (p. 98).

Following the *Frascati Manual*, R&D efforts, and R&D personnel and researchers are classified in five main sectors (institutional classification): business enterprise (BES), government (GOV), private non-profit (PNP), higher education (HE) and abroad. The business enterprise sector includes 'all firms, organisations and institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price' (p. 54)\(^8\). The government sector covers: 'all departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community.' (p. 62). The private non-profit sector includes 'non-market, private non-profit institutions serving households (i.e. the general public) [and] private individuals or households' (p. 64). The higher education sector is composed of 'all universities, colleges of technology and other institutions of post-secondary education,

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\(^8\) For more details, see *Frascati Manual*, Chapter 3, p. 51-73.
whatever their source of finance or legal status [and] also [...] all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education institutions.' (p. 68).

The measurement of personnel employed in R&D involves two exercises:

- measuring their number in headcounts (HC);
- measuring their R&D activities in full-time equivalence (FTE) = person-years.

2.1.2.1 HC data

Data on the total number of persons who are mainly or partially employed in R&D (HC data) allow links to be made with other data series, (for example, education or employment data or the results of population censuses). This is particularly important when examining the role of R&D employment in total stocks and flows of scientific and technical personnel. HC data are also the most appropriate measure for collecting additional information about R&D personnel, such as age, gender or national origin. Such data are needed to conduct analytical studies and implement recruitment or other S&T policies.

Various options are available for reporting headcount numbers:

- number of persons engaged in R&D at a given date (e.g. end of period);
- average number of persons engaged in R&D during the (calendar) year;
- total number of persons engaged in R&D during the (calendar) year.

2.1.2.2 FTE data

R&D may be the primary function of some persons or it may be a secondary function. It may also be a significant part-time activity (e.g. university teachers or postgraduate students). To include only persons whose primary function lies with R&D would result in an underestimate of the effort devoted to R&D; to do a headcount of everyone spending some time on R&D would lead to an overestimate. The number of persons engaged in R&D is, therefore, also expressed in full-time equivalents on R&D activities (FTE data). This is a 'true' measure of the volume of R&D.

Diverse methods can be used for measuring FTE data. The most precise method involves carrying out time-use surveys for each individual researcher. However, more approximate methods are often used in practice. One method used often involves counting the number of positions for each category of personnel, then multiplying by appropriate R&D coefficients. In some cases, the R&D coefficients used are founded on survey data of some sort, while in others they are simply based on assumptions made by those who compile the statistics⁹.

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⁹ For instance, teacher-researchers in France are conventionally supposed to devote 50% of their time to teaching and 50% of their time to research.
To obtain appropriate data on R&D personnel in the higher education sector, time-use surveys or studies should be carried out. The main problem is related to the definition of the working time, which varies according to number of teaching hours per week, examinations, supervision and administrative duties, nature of R&D activities, etc.

### 2.1.3 HRST, R&D personnel and researchers in the EU

To statistically illustrate the importance of the various groups that have been defined, results on the numbers of HRST, sub-groups of HRST, R&D personnel and researchers are given for the EU-25 in 2004\(^{10}\), in the following table.

The active population was estimated to be about 214 million in the EU-25 in 2004. HRST accounted for 40.4% of this total. HRSTE (defined in terms of Education only) accounted for 28.7% and HRSTO (Occupations) for 26.6%. HRSTC (Core, i.e. defined both in terms of Education and Occupations) accounted for nearly 15%, and scientists and engineers for 4.4%. Total R&D personnel (HC) accounted for 2.9 million, 1.36% of the active population.

Researchers, the group to which most of the rest of this section will be devoted, accounted for 0.84% of the active population if measured in HC, i.e. nearly 1.8 million, and 0.57% (1.2 million) if measured in FTE.

| Table 1. HRST, sub-groups of HRST, scientists and engineers, R&D personnel and researchers in the EU-25 in 2004 |
|-------------------------------------------------|-----------------|-----------------|
| Active Population                               | 213 834         | 100.0           |
| HRST                                           | 86 338          | 40.4            |
| HRSTE                                          | 61 322          | 28.7            |
| HRSTO                                          | 56 843          | 26.6            |
| HRSTC                                          | 31 827          | 14.9            |
| Scientists and engineers                       | 9 411           | 4.4             |
| Total R&D personnel (HC)                       | 2 905           | 1.36            |
| Researchers (HC)                               | 1 787           | 0.84            |
| Researchers (FTE)                              | 1 217           | 0.57            |

Source: JRC-IPTS based on Eurostat data. HRST and sub-groups are between 15 and 74 years old.

The sizes of HRST and the four sub-groups (25-64 years old) are presented in Table 2. HRST accounted for 82.4 millions in EU-27 at a whole, or 37.7% of the labour force, in 2005. The number of HRST Core was 33.2 millions, 16.6% of the labour force, and the number of scientists and engineers 10.1 millions, or 5% of the active population. Within EU-27, HRSTC accounted for between 9.9% of labour force in Romania and 26.5% in Denmark. The share of scientists and engineers in labour force ranged from 2.6% in Slovakia to 7.9% in Belgium.

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\(^{10}\) The last most complete year.
Table 2. HRST and sub-groups, in thousands and as percentage of labour force, 25-64 years old, in EU Member States (2005)

<table>
<thead>
<tr>
<th></th>
<th>HRST</th>
<th>%</th>
<th>HRSTE</th>
<th>%</th>
<th>HRSTO</th>
<th>%</th>
<th>HRSTC</th>
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<td>4 570</td>
<td>18.7</td>
<td>1 329</td>
<td>5.4</td>
</tr>
</tbody>
</table>

EU-27       82 441 | 37.7| 58 806 | 25.9| 56 837 | 28.4| 33 202| 16.6| 10 064| 5  

Source: JRC-IPTS based on Eurostat data.

2.2 Researchers: elements of international comparison
(EU/US/Japan/China/OECD)

Table 3 considers the 'smaller' group (researchers, FTE) and gives results for the EU, US, Japan and the total for OECD countries.

In 2005, there were 1.4 million researchers in the US, 1.3 million in the EU-27, 1.1 million in China and 704 000 in Japan.\textsuperscript{11} The total for the OECD region was 3.9 million. Demand for researchers was greater in Japan (1.06% of labour force) and the US (0.93%) than in the EU-27 (0.56%) and China (0.15%). It was 0.70% on average in the OECD. Within EU-27, demand for researchers was the highest in Finland (1.50% of labour force), Sweden (1.19%) and Denmark (0.98%), and the lowest in Romania (0.22%) and Cyprus (0.17%) (Figure 1). 15 EU Member States out of 27 had a number of researchers as percentage of labour force lower than 0.5% in 2005.

\textsuperscript{11} Data comparability problems may exist.
The share of business researchers in the total number of researchers differs widely between the EU-27 (48%) and the US (79%), Japan and China being in-between with 68% and 62% respectively. Business researchers account for 0.27% of labour force in the EU-27, 0.09% in China, 0.72% in Japan and 0.74% in the US. Within EU-27, the share of researchers employed in the business sector ranges from 9.4% in Lithuania to 76.1% in Luxembourg. Countries above 60% are Denmark, Germany, Luxembourg, Austria and Sweden. Countries below 30% are Bulgaria, Estonia, Spain, Italy, Cyprus, Latvia, Lithuania, Poland, Portugal and Slovakia. For the 27 EU Member States, there seems to be a positive relation between the share of business researchers and the total number of researchers as percentage of labour force (Figure 1).

Table 3. Researchers (FTE) and researchers in the business sector (FTE), number and percentage of active population, in the EU-27, US, Japan, China and OECD (2005)

<table>
<thead>
<tr>
<th></th>
<th>Researchers, Total In thousands</th>
<th>Percentage of labour force</th>
<th>Business researchers In thousands</th>
<th>Percentage of labour force</th>
<th>Share of business researchers in total Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU-27</td>
<td>1 301</td>
<td>0.56</td>
<td>629</td>
<td>0.27</td>
<td>48.3</td>
</tr>
<tr>
<td>EU-25</td>
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<td>0.58</td>
<td>617</td>
<td>0.28</td>
<td>48.7</td>
</tr>
<tr>
<td>US</td>
<td>1 395</td>
<td>0.93</td>
<td>1 105</td>
<td>0.74</td>
<td>79.2</td>
</tr>
<tr>
<td>Japan</td>
<td>705</td>
<td>1.06</td>
<td>481</td>
<td>0.72</td>
<td>68.3</td>
</tr>
<tr>
<td>China</td>
<td>1 119</td>
<td>0.15</td>
<td>696</td>
<td>0.09</td>
<td>62.3</td>
</tr>
<tr>
<td>OECD</td>
<td>3 891</td>
<td>0.70</td>
<td>2 496</td>
<td>0.45</td>
<td>64.2</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS based on OECD data.
The number of researchers (FTE) increased from 964 000 in 1995 to 1.3 million in 2005 in the EU-27 (+3.0% per year; cf. Figure 2). Over the same period, the increases were 3.0% per year in the US (from 1.04 million to 1.39 million), 0.5% in Japan (from 673 000 to 705 000), 7.9% in China (from 522 000 to 1.12 million), and 3.3% in the total OECD (from 2.8 million to 3.9 million).

Over the period 2000 to 2005, the growth in the number of researchers (FTE) was faster in the EU-27 (+3.6% p.a.) than in the US (+1.6%), Japan (+1.7%) and the OECD average (+2.9%), while China experienced a growth of 10% per year.
The number of researchers (FTE) in the business sector increased from 436 000 to 629 000 in the EU-27 (Figure 3), which corresponds to an annual growth of 3.7%. In the US, it increased from 789 000 to 1 105 000 (+3.4% p.a.), and in Japan from 384 000 to 481 000 (the growth was less strong, with 2.3% per year on average). In China, the growth was strong, from 193 000 to 696 000 (+13.7% p.a.). In the total OECD region, the number increased from 1.74 million to 2.5 million (+3.7% p.a.).
The total number of researchers as a share of the active population increased from 0.44% in 1995 to 0.56% in 2005 in the EU-27 (+0.12 percentage points; Cf. Figure 4). Over the same period, the increase was slightly more pronounced in the US (from 0.77% to 0.93%; but the highest share was observed in 2004 with 0.95%). In all OECD countries, the share increased from 0.55% to 0.70%, and in China it increased from 0.08% to 0.15%.

The share of business researchers in the active population (Figure 5) increased from 0.20% in 1995 to 0.27% in 2005. In the US the increase has been stronger, from 0.59% to 0.74% (but the highest point was attained in 2004 with 0.76%). In Japan, we observed a similar increase in percentage points, from 0.58% to 0.72%. In China, the increase was less regular, but it varied from 0.028% in 1995 to 0.091% in 2005. In all the OECD countries, the share of business researchers grew from 0.34% to 0.45%.

**Figure 4. Number of researchers (FTE) as a percentage of the active population in the EU-27, US, Japan and China (1995-2005)**

Source: JRC-IPTS based on OECD data.
2.3 Evolution of the number of researchers in the EU over the last decade

2.3.1 The total number of researchers in the EU: an increase of 3% per year over the last decade

The number of researchers in the EU increased from 1.36 million (in headcount terms, which amounts to 927 000 in full time equivalent) in 1995 to 1.79 million (1.22 million in FTE) in 2004. This represents an annual growth rate of 3%. This corresponds to an increase of about 50 000 researchers (HC) per year. The percentage of researchers (HC) in the active population also shows an upward trend, having risen from 0.76% in 1999 to 0.83% in 2004.
This growth in the number of researchers is matched by a slightly lower growth in expenditures (2% a year, in constant prices). This can be interpreted either as a sign of the expansion of the European R&D system, or as the increased effectiveness of R&D statistics. The slight mismatch between the increase in researchers and in expenditures can be explained by a more rapid growth in scientific disciplines (e.g. the social sciences) and industrial sectors (e.g. services) that are more labour intensive and less demanding in terms of equipment.

However, these figures for Europe are based on very diverse national settings. Regarding the percentage of researchers in the active population, some countries in 2004 were still below the 0.5% level (Bulgaria, Italy, Cyprus, Latvia and Romania). The only countries above 1% were Denmark, Luxembourg, Austria and Finland.
Source: JRC-IPTS with Eurostat data. Note: data from 2003 for Belgium, Germany, Greece, Luxembourg, Netherlands, Portugal and Sweden.

Over the recent period (2000-05), the number of full-time equivalent researchers in the EU-27 has increased by 3.6% per year. Within EU-27, the strongest average annual growth rates have been observed in Malta, Cyprus, Czech Republic and Denmark. Slight decreases have taken place in Latvia, Lithuania, Netherlands and Slovenia. EU-27 experienced as well an increase in the number of researchers (FTE) per one thousand labour force from 4.87 in 2000 to 5.64 in 2005, which corresponds to an average annual growth rate of 3%. Many EU Member States enjoyed a significant growth in the number of researchers per one thousand labour force, in particular Czech Republic and Denmark. To the contrary, three EU Member States experienced a decrease (Latvia, Slovenia, Netherlands). For the 27 EU Member States, there is a negative correlation, but quite loose, between the initial level of the number of researchers (FTE) per one thousand labour force in 2000 and the growth observed over 2000-05 in the number of researchers (FTE) per one thousand labour force, which could be interpreted as a slight convergence (Figure 8).
2.3.2 The number of researchers in the public sector: growth has been driven by the HE sector over the last decade

For the past ten years, the stock of (FTE) researchers in the EU-25 in the public sector has been growing quite steadily, at an average rate of 2% a year. This growth is mainly due to the higher education sector, which has shown an average annual growth rate of 3%, whereas the government sector has remained fairly stable. The number of researchers (FTE) in the public sector has reached 605 000 in 2004.
Regarding the differences by EU country, it is noticeable that almost all countries have contributed to the growth of researchers in the public sector, with the exception of Italy, the Netherlands, Slovenia and the UK, where the number of researchers has decreased between 1995 and 2004. Spain shows the most significant increase in the number of researchers over the ten-year period, almost doubling its public researchers stock\(^\text{12}\).

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\(^\text{12}\) However, this may be partly due to a change in definitions and methodology, according to a Spanish expert. In 2002, the methodology of the statistics on research and development changed. Until 2002, the definition of researchers according to the *Frascatti Manual* was ambiguous, so the number of researchers in Europe was not harmonised. For example, in Spain, until 2002, for someone to be considered a researcher, he/she had to work full-time and exhibit that he/she was constantly exerting his best efforts to complete the research. Until 2002, the occasional researchers were not taken into consideration in the R&D statistics. In addition, many non-profit institutions were classified as part of the private sector.
2.3.3 The number of researchers in the business sector: a growth differentiated by areas of activity

The business sector in Europe shows an even clearer tendency for growth regarding the number of researchers, since the average annual growth rate between 1995 and 2004 is double the one observed for the public sector (4% for HC, 4.1% for FTE).
Figure 11. Researchers (HC, FTE) in the business sector in the EU-25 (1995-04)

Source: JRC-IPTS with OECD and Eurostat data.

Although this may be partially attributed to an improvement in survey techniques and a larger coverage of enterprises, and to a re-classification of some activities as research for tax purposes, the size of the growth must also be due to an expansion of the business R&D system.

This growth in the stock of researchers in the business sector has not occurred homogenously in all areas of activity. Whereas some sectors lost researchers between 1995 and 2004 (chemicals, manufacture of office machinery and computers), other sectors more than doubled their stock of researchers: manufacture of motor vehicles, computer and related activities, research and development.

During this period, the growth rate in the services sector was higher than in the manufacturing sector (average annual growth rate of 8% against 3%).
Figure 12. Researchers (FTE) in the business sector by selected NACE sectors in the EU-25 (1995 and 2004)

Source: JRC-IPTS with Eurostat data.

However, data by sector must be analysed with some caution. For example, the research and development services sector has different classifications in different countries that sometimes change over time. A company that provides R&D services to other companies may be classified either in this sector or in the other sectors to which its research belongs (e.g. pharmaceuticals, manufacture of motor vehicles).

**Methodology of section 2.3: the stock of researchers**

The Frascati Manual's definition for researchers is used, as applied in R&D surveys, which are the source for Eurostat and OECD R&D statistics: 'Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned'; this targets highly qualified people, working either in enterprises or public institutions, in charge of designing and managing research projects aimed at meeting the needs of their employers (mostly basic research needs for public institutions and applied research and development needs for business enterprises).

FTE is the unit used in most charts, since there is more data available than for HC. On the other hand, it allows for a clearer picture of the stock of researchers, since it measures the actual time devoted to research, and not the amount of individuals that perform research, often on a part-time basis. However, in the nowcasting exercise, data in head counts will be preferred as it is more relevant to the perspective of a supply-demand analysis. Finally, the relations between the HC and FTE data series are relatively close (the two series evolve in parallel) and generally one series can be approximated very closely from the other.
Although the reference year for most countries in Figure 7 is 2004, data for Belgium, Germany, Greece, Luxembourg, the Netherlands, Portugal and Sweden are from 2003. No information was found regarding the UK.

Data by country in Figure 10 was obtained from several sources: Eurostat, OECD and national statistical agencies. The values for Austria were estimated through annual growth rates, since the only available figures date from 1993, 1998 and 2002. The values for 2004 for France, Italy, the Netherlands and the UK were also estimated based on annual growth rates between 2001 and 2003.

The values by sector in Figure 12 were also obtained from several sources: Eurostat, OECD and national statistical agencies (France, the UK and Finland). The EU total was estimated based on the sum of 19 countries, which concentrate 99% of the total business researchers in Europe: Austria, Belgium, the Czech Republic, Germany, Denmark, Spain, Finland, France, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Sweden, Slovenia and the UK.

2.4 Forecasting the number of researchers

The aim of this section is to give short-term (2005-07) and medium-term (2010) forecasts of the number of researchers. Econometric models have been applied to estimate the total number of researchers and the number of researchers in the different sectors, at the EU-25 level.

2.4.1 Short-term forecasts (2004-2007): growth in the number of researchers is expected to be 3.5% per year in the HE sector and 3.2% per year in the business sector

According to our estimations, there should be about 1.95 million researchers (HC) in the EU-25 in 2007. The increase will be about 9.2% from 2004 to 2007, i.e. 3% per year, which corresponds to about 165 000 more researchers (+55 000 per year).

The number of researchers in higher education is estimated to be about 970 000 in 2007, an increase of about 10.8% from 2004 (3.5% per year), i.e. an increase in the absolute number of researchers of about 94 000 researchers. The number of researchers in the government sector was estimated to be about 195 000 in 2007, more or less at the same level as in 2004. Therefore, in the public sector (if we add the higher education and the government sectors), the number of researchers was estimated to be 1.16 million in 2007 in the EU-25 (an additional 94 000 researchers in the 2004 to 2007 period, i.e. +8.8%).

The number of researchers in the private non-for-profit sector was estimated to be about 21 000 in 2007, an increase of about 3 000 researchers from 2004.

According to the models, the number of researchers (HC) in the business sector in the EU-25 should be around 770 000 in 2007. The increase is 9.8% (3.2% per year) compared to 2004, which corresponds to about 70 000 additional researchers.

Over the period 2004 to 2007, in the EU-25, the number of researchers in the business sector was expected to grow slightly more rapidly (in percentage) than the number of researchers in the public sector (3.2% against 2.8% per year). However, in absolute numbers, the conclusion is different as the number of researchers was expected to increase more in the public sector than in the business sector (94 000 against 68 000).
Table 4. Number of researchers (HC) in 2004 (observed) and 2007 (estimated) in the EU-25

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2007</th>
<th>Variations</th>
<th>Growth rates (%)</th>
<th>Annual growth rates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector</td>
<td>1 068 000</td>
<td>1 162 000</td>
<td>94 000</td>
<td>8.8</td>
<td>2.8</td>
</tr>
<tr>
<td>HE</td>
<td>873 000</td>
<td>967 000</td>
<td>94 000</td>
<td>10.8</td>
<td>3.5</td>
</tr>
<tr>
<td>GOV</td>
<td>195 000</td>
<td>195 000</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>PNP</td>
<td>18 000</td>
<td>21 000</td>
<td>3 000</td>
<td>15.9</td>
<td>5.2</td>
</tr>
<tr>
<td>BES</td>
<td>700 000</td>
<td>769 000</td>
<td>68 000</td>
<td>9.8</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1 787 000</td>
<td>1 952 000</td>
<td>165 000</td>
<td>9.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS. Numbers are rounded.

2.4.2 Medium-term forecasts (2000-2010): an expected increase of 50 000 researchers per year, shared equally between the HE sector and the business sector

It is possible to try to forecast the number of researchers up to 2010. This is done simply with linear trend models. We found that nearly 2.1 million researchers will be employed in the EU-25 in 2010, nearly 1.24 million in the public sector and 830 000 in the business sector.

This corresponds to an increase of about 510 000 researchers in the period from 2000 to 2010, i.e. an increase of some 50 000 researchers per year, shared equally between the higher education (+25 000 per year) and the business (+25 000 per year) sectors.

The annual growth rate of the number of researchers is expected to be 2.8% on average, with 3.7% in the business sector and 2.8% in the higher education sector.

Table 5. Number of researchers (HC) in 2000 (observed) and 2010 (estimated) in the EU-25

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2010</th>
<th>Variations</th>
<th>Growth rates 2000-2010 (%)</th>
<th>Annual growth rates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public sector</td>
<td>994 000</td>
<td>1 245 000</td>
<td>251 000</td>
<td>25.3</td>
<td>2.3</td>
</tr>
<tr>
<td>HE</td>
<td>801 000</td>
<td>1 051 000</td>
<td>251 000</td>
<td>31.2</td>
<td>2.8</td>
</tr>
<tr>
<td>GOV</td>
<td>193 000</td>
<td>193 000</td>
<td>1 000</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>PNP</td>
<td>17 000</td>
<td>23 000</td>
<td>6 000</td>
<td>35.3</td>
<td>3.1</td>
</tr>
<tr>
<td>BES</td>
<td>580 000</td>
<td>834 000</td>
<td>254 000</td>
<td>43.8</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1 591 000</td>
<td>2 102 000</td>
<td>511 000</td>
<td>32.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS. Estimations are based on linear trend models. Numbers are rounded.
Methodology of section 2.4: forecasting

To evaluate the current values and the evolutions of the number of researchers in the near future on the basis of available information, as official data are generally delayed for two or three years, three models have been estimated: the first one has only GDP as an explanatory variable; the second one has GDP and a trend as explanatory variables (our 'central' model); and the third one has only trend as a variable. The variable GDP captures the impact of general economic conditions, whereas the trend variable is intended to capture the exogenous component in the number of researchers. GDP was chosen as it is forecast for the next two years and thus can be used to nowcast the number of researchers. The results presented in this section are those of the central model if not otherwise stated.

Data

Data were extracted on 6 October 2006, from the Eurostat database.

Definitions

Nowcasting involves making an inference on the current realisation of random variables, using recent information available. The method tries to evaluate the current values of some series (e.g., R&D, gross domestic product (GDP), inflation), on the basis of available and delayed data.

Borrowing from the meteorological literature, this problem is called nowcasting rather than short-term prediction, in order to emphasise the fact that when nowcasting, the time of availability of the data is not the same for all variables, particularly for the possible predictors, and to emphasise that the horizon of prediction is today rather than tomorrow (Moucharta et al., 2005).

Nowcasts are constructed at central banks, using both simple models and qualitative judgment. These exercises involve the analysis of a large amount of information and a judgment on the relative weight to attribute to various data series. As new information becomes available throughout the month, the nowcasts and forecasts may be adjusted in response to changes in both the values of the data series and the implicit relative weights applied to those series (Giannone et al., 2005).

Estimation methods

Three models have been estimated:

Model 1: \( RES_t = \alpha + \beta GDP_t + u_t \quad u_t \sim N(0; \sigma^2) \quad t = 1995\ldots2004 \)

Model 2: \( RES_t = \alpha + \beta GDP_t + \delta t + u_t \quad u_t \sim N(0; \sigma^2) \quad t = 1995\ldots2004 \)

Model 3: \( RES_t = \alpha + \delta t + u_t \quad u_t \sim N(0; \sigma^2) \quad t = 1995\ldots2004 \)

\[ \text{In contrast with R&D expenditures, for example, which may have been more relevant but are generally not forecast (moreover, they are generally subject to delays as well), and thus can’t be used for our purposes.} \]

\[ \text{The results of the two other models are very similar; they have not been reported here to avoid further complicating this document.} \]
Here, RES is the number of researchers (HC), GDP is the gross domestic product at constant prices (index 1995 = 100), t is the year, u is the error term, and α, β and δ are the parameters to estimate.

These models have been applied to the total number of researchers, to the number of researchers in the different sectors taken individually (HE, GOV, PNP, BES) or grouped (total for HE-GOV-PNP).

Eurostat data have been used to feed the models.

Model 2 is our 'central' model. It is generally preferred to the other models as its quality has been proven to be higher, except in some cases when HE, GOV and PNP were considered separately.

Model 3 has mainly been used for the medium-term forecasts dating to 2010 (it is a simple linear trend model).

Quality

The models are satisfactory in general, as around 95% to 99% of the variance is explained, When HE, GOV and PNP are considered separately, the models perform less well as only about 40% to 50% of the variance is explained.

However, the nowcasts of the number of researchers are dependent upon the quality of the forecasts of GDP. A more general problem remains the impossibility of forecasting the exogenous shocks (and notably policy measures). More complex models could be estimated but the added value is uncertain.

Brief bibliography


3 The supply of higher education graduates and postdoctorates in the European Union

Section 3.1 will discuss the recent evolution of the number of tertiary graduates in the EU. Section 3.2 will present the results of the estimation of the number of postdoctorates in three fields (life sciences, engineering, social sciences).

3.1 Higher education graduates in the EU

This section describes the evolution of the number of higher education degrees in the EU-27 from 1998 to 2005. It is devoted to the analysis of tertiary degrees with academic orientation (ISCED 5A) and to doctoral degrees (ISCED 6)\(^{15}\), as they are the main component of the potential supply of scientists and researchers. In the terminology of the International Standard Classification of Education (ISCED-97), ISCED level 5A programmes are tertiary programmes that are largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programmes and professions with high skills requirements. The ISCED 6 level, 'second stage of tertiary education leading to an advanced research qualification', is reserved for tertiary programmes that lead to the award of an advanced research qualification.

The cumulated number of tertiary degrees with academic orientation conferred for the period 1998 to 2005 in the EU-27 reached 19.6 million (2.45 million each year on average) (cf. Table 6). In 2005, 3 million such degrees were conferred\(^{16}\).

The cumulated number of doctoral degrees over the same period was 686 000, i.e. 86 000 per year on average. In 2005, 101 000 doctoral degrees were granted.

In science, mathematics and computing, nearly 248 000 tertiary degrees with academic orientation and 24 800 doctoral degrees were conferred each year on average over the same period. The corresponding numbers for 2005 are 307 000 and 27 500.

In engineering, manufacturing and construction, 306 000 tertiary degrees with academic orientation and 11 600 doctoral degrees were conferred from 1998 to 2005. In 2005, these numbers were respectively 358 000 and 13 400.

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\(^{15}\) Please see the methodology for more details.

\(^{16}\) When the calculations were performed (November 2007), data for 2005 were not complete for Italy. Instead, 2004 data were used for this country.
In the rest of this section, we will first study the evolution of the number of tertiary degrees with academic orientation, by fields and countries, over the period 1998 to 2005. Then the evolution of doctoral degrees will be detailed over the same period. Finally, some elements on gender differences will be given.

### 3.1.1 Tertiary degrees with academic orientation

#### 3.1.1.1 Elements of international comparison

In 2005, 3 million tertiary degrees with academic orientation were conferred in the EU-27, against 2.1 million in the US and 640 000 in Japan (Figure 13). From 1998 to 2005, a regular increase was observed: the number of degrees increased by 6.7% per year on average in the EU-27, 3.3% in the US and 1.3% in Japan.

The share of science and engineering (S&E) degrees in this total tended to decrease slightly over the same period in the EU-27, from 23.7% in 1998 to 21.9% in 2005. In the US, the share of S&E degrees is lower and was more or less stable, ranging between 14.4% and 15.9% over the same period. In Japan, the share of S&E degrees, which is higher than in the US and (slightly) higher than in the EU-27, decreased very slightly, from 25.8% to 24.5%.

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**Table 6. Number of HE degrees conferred in the EU-27 (cumulated over the period 1998 to 2005 and in 2005)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Tertiary degrees with academic orientation (ISCED 5A)</th>
<th>Doctoral degrees (second stage of tertiary education leading to an advanced research qualification) (ISCED 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher training and education science</td>
<td>2,257,954</td>
<td>282,244</td>
</tr>
<tr>
<td>Humanities and arts</td>
<td>2,495,206</td>
<td>311,901</td>
</tr>
<tr>
<td>Social sciences, business and law</td>
<td>6,941,420</td>
<td>867,678</td>
</tr>
<tr>
<td>Science, mathematics and computing</td>
<td>1,980,122</td>
<td>247,515</td>
</tr>
<tr>
<td>Engineering, manufacturing and construction</td>
<td>2,444,536</td>
<td>305,567</td>
</tr>
<tr>
<td>Agriculture and veterinary</td>
<td>328,291</td>
<td>41,036</td>
</tr>
<tr>
<td>Health and welfare</td>
<td>1,911,622</td>
<td>238,953</td>
</tr>
<tr>
<td>Services</td>
<td>563,975</td>
<td>70,497</td>
</tr>
<tr>
<td>Unknown or not specified</td>
<td>680,609</td>
<td>85,076</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19,603,735</strong></td>
<td><strong>2,450,467</strong></td>
</tr>
</tbody>
</table>

Source: JRC-IPTS with Eurostat data.
When viewing the science and engineering fields separately, we find that some 300 000 degrees in science were conferred in 2005 in the EU-27, against 190 000 in the US and 28 000 in Japan (Figure 14). In engineering, 60 000 degrees were granted in the EU-27, 130 000 in the US and 130 000 in Japan.

The share of science degrees in the total number of degrees with academic orientation is therefore slightly higher in the EU-27 than in the US and Japan, 10.1% against 9% and 4.4%. In engineering, the share of the number of degrees in total is also higher in the EU-27 than in the US, 11.8% against 6.2%. In Japan, however, the share of degrees in engineering is far higher, with 20.1%.

From 1998 to 2005, the number of science degrees increased regularly by 6.8% per year on average in the EU-27 (more or less at the same pace as the total number of degrees). In the US it increased by 3.6% (slightly more than the total) and in Japan by 1.8% (slightly more than the total as well). In engineering, the growth in the number of degrees was less strong in the three areas, 4.5% on average in the EU-27, 1.8% in the US and 0.3% in Japan.

Therefore, the share of science degrees in the total number of degrees with academic orientation was relatively stable in the EU-27 (around 10%), while the share of engineering degrees decreased slightly. To the contrary, in the US, the share of science degrees tended to grow slowly (except in 2004 and 2005), while the share of engineering degrees decreased slightly. In Japan, the share of science degrees remained relatively stable and the share of engineering degrees decreased slightly.

17 A drop in the number of science graduates is observed that year. This may be related to a problem in data.
3.1.1.2 EU-27 level

The number of degrees with academic orientation granted in the EU-27 increased on average by 6.7% per year (+1.1 million degrees) between 1998 and 2005 (Table 7 and Figure 15). It increased in all fields, but the highest growth was seen in services (+12.7% p.a.), health and welfare (+10.0% p.a.) and the social sciences, business and law (+8.7% p.a.).

In science, mathematics and computing, the number of degrees increased more or less at the same pace as the average, i.e. 6.8% p.a. (+113 000 degrees), while in engineering, manufacturing and construction, the increase was less pronounced (+4.5% p.a., +85 000 degrees).

The development of the shares of degrees by disciplines in the total reflects this trend. The share of the social sciences, business and law degrees in the total number of degrees with academic orientation increased from 34.6% in 1998 to 38.2% in 2005. There was stagnation for science, mathematics and computing degrees (from 10.4% to 10.2%) and a decrease in engineering, manufacturing and construction (from 14.1% to 11.8%).

Source: JRC-IPTS based on Eurostat data.
### Table 7. Number of tertiary degrees with academic orientation conferred in the EU-27, by main fields (1998 and 2005)

<table>
<thead>
<tr>
<th>Field</th>
<th>1998</th>
<th>%</th>
<th>2005</th>
<th>%</th>
<th>Variation</th>
<th>Growth rate</th>
<th>Annual growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher training and education science</td>
<td>231,356</td>
<td>12.4%</td>
<td>336,384</td>
<td>11.1%</td>
<td>105,028</td>
<td>45.4%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Humanities and arts</td>
<td>280,871</td>
<td>15.0%</td>
<td>379,104</td>
<td>12.5%</td>
<td>98,233</td>
<td>35.0%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Social sciences, business and law</td>
<td>645,884</td>
<td>34.6%</td>
<td>1,154,997</td>
<td>38.2%</td>
<td>509,113</td>
<td>78.8%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Science, mathematics and computing</td>
<td>194,120</td>
<td>10.4%</td>
<td>307,402</td>
<td>10.2%</td>
<td>113,282</td>
<td>58.4%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Engineering, manufacturing and construction</td>
<td>263,212</td>
<td>14.1%</td>
<td>358,473</td>
<td>11.8%</td>
<td>95,261</td>
<td>36.2%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Agriculture and veterinary</td>
<td>34,600</td>
<td>1.9%</td>
<td>48,305</td>
<td>1.6%</td>
<td>13,705</td>
<td>39.6%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Health and welfare</td>
<td>174,964</td>
<td>9.4%</td>
<td>340,263</td>
<td>11.2%</td>
<td>165,299</td>
<td>94.5%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Services</td>
<td>43,577</td>
<td>2.3%</td>
<td>100,791</td>
<td>3.3%</td>
<td>57,214</td>
<td>131.3%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Total</td>
<td>1,868,584</td>
<td>100.0%</td>
<td>3,025,719</td>
<td>100.0%</td>
<td>1,157,135</td>
<td>61.9%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Unknown or not specified</td>
<td>62,033</td>
<td></td>
<td>14,046</td>
<td></td>
<td>-47,987</td>
<td></td>
<td>-19.1%</td>
</tr>
<tr>
<td>Total with unknown or not specified</td>
<td>1,930,617</td>
<td></td>
<td>3,039,765</td>
<td></td>
<td>1,109,148</td>
<td>57.5%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS with Eurostat data.

### Figure 15. Number of tertiary degrees with academic orientation in the EU-27, by field (1998-2005)

Source: JRC-IPTS based on Eurostat data.

#### 3.1.1.3 Evolution by country

### All fields

Poland\(^\text{18}\), the UK, France and Italy conferred the highest numbers of higher education degrees with academic orientation in 2005, between 350,000 and 500,000 each (Figure 16). Germany

\(^{18}\) Very few degrees are awarded in the ISCED 5B category in this country, according to Eurostat data.
and Spain, the two following countries on the list, conferred around 200 000 degrees. These 6 top countries accounted for about 73% of the total number of degrees conferred in the EU-27 in 2005. All the other countries conferred less than 150 000 degrees.

All countries experienced a growth of the number of degrees between 1998 and 2005, except Spain, which exhibited a slight decrease of -0.8% on average per year. The highest growth rates over the period 1998 to 2005 are found in Denmark (19.4% p.a.), Latvia (13.0%) and Romania (12.4%).

**Figure 16. Tertiary degrees with academic orientation: number in 2005 and average annual growth rate over the period 1998 to 2005, by country**


**S&E fields**

In the science and engineering fields (grouping together the fields 'science, mathematics and computing' and 'engineering, manufacturing and construction'), France and the UK conferred the highest number of tertiary degrees with academic orientation in 2005, 120 000 and 110 000 respectively. The top following countries are Italy, Poland, Germany and Spain, which delivered between 47 000 and 78 000 degrees. These 6 countries accounted for about 74% of the EU-27 total in these fields. With the exception of Romania, which conferred 31 000 degrees, all the other countries delivered less than 16 000 degrees in these fields.
Figure 17. Tertiary degrees with academic orientation in S&E fields: number in 2005 and average annual growth rate over the period 1998 to 2005, by country


Over the period 1998 to 2005, the number of degrees in S&E fields increased in all countries excepting Germany and Slovenia (quasi-stability) and Hungary (slight decrease of 1.1% per year). Growth was strongest in Cyprus, Malta, Estonia, Denmark, Slovakia, Poland, Portugal and Romania (higher than 10% per year in each of these countries).
In science, mathematics and computing, the UK and France delivered the highest number of degrees with academic orientation in 2005, with 70,000 and 66,000 degrees conferred respectively (Figure 18). They are followed by Poland, Germany, Italy and Spain, which conferred between 18,000 and 32,000 degrees. These six countries accounted for about 78% of the EU-27 total. All the other countries conferred less than 10,000 degrees in 2005.

All countries show a positive growth in the number of degrees with academic orientation in science, mathematics and computing conferred between 1998 and 2005. In the UK, a strong growth was observed from 1998 (50,900) to 2003 (79,300) that was interrupted in 2004 (69,400) and 2005 (70,200). In France, the number fluctuated between 53,200 in 1998 and 65,700 in 2005. Poland, the third top country, had the strongest growth observed for all countries (+30% per year), going from 5,100 degrees in 1998 to 32,600 in 2005. In Germany, a decrease was observed from 1998 (24,100) to 2001 (19,400), followed by strong regular increase to 30,000 in 2005. In Italy, it was relatively stable over the period 1998 to 2001 and then strongly increased. In Spain, the number slightly increased over the period 1998 to 2001 and then decreased, making it stable over the whole period.

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19 See also Figure 20, where the detailed patterns of the number of science and engineering degrees over the period 1998 to 2005 are represented for the top 10 countries in terms of S&E degrees in 2005.

20 Note that data are not complete, since for the years 2002 and 2004, no data are provided.
In engineering, manufacturing and construction, Italy and France conferred the highest number of tertiary degrees with academic orientation in 2005, respectively 54,900 and 54,300 (Figure 19). The UK, Poland, Germany and Spain are the top following countries, each of them conferring between 29,000 and 41,000 degrees. These 6 countries accounted for about 70% of the EU-27 total. All the other countries conferred less than 10,000 degrees in these fields (except Romania, which conferred 24,000 degrees).

Over the period 1998 to 2005, the UK, Germany, the Netherlands, Hungary and Slovenia experienced a decrease in the number of degrees conferred in these fields. In the UK, the number of degrees declined from 1998 to 2004, but increased slightly in 2005. In Germany, the number of degrees decreased from 1998 to 2002, attaining a low level of 32,800, and then increased. In Italy, it strongly increased over the period and particularly from 2001 to 2005, and in France it decreased from 1998 to 1999, was stable and then increased from 2000 to 2005. In Spain, it grew from 1998 to 2003 and then decreased in 2004 and 2005.
Figure 20. Number of S&E degrees with academic orientation and share in the total number of degrees with academic orientation: evolution from 1998 to 2005, top 10 EU countries

Source: JRC-IPTS based on Eurostat data.
Share of S&E fields

The highest share of science and engineering fields among the total number of degrees with academic orientation is found in Germany (30.8%) and Finland (29.5%) (cf. Figure 21).

Distinguishing between science on the one hand and engineering on the other, the highest share of science, mathematics and computing degrees was found in Cyprus with 20.8% \(^{21}\), Greece (17.8%) and Ireland (15.9%). In engineering, manufacturing and construction, the highest share was found in Finland (21.4%), Sweden (18.3%) and Slovakia (17.6%)\(^{22}\).

Figure 21. Share of S&E degrees in the total number of degrees with academic orientation in 2005, by country (%)

Source: JRC-IPTS based on Eurostat data.

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\(^{21}\) However, with 166 out of the 800 degrees.

\(^{22}\) The evolution of the share of science and engineering degrees is provided in Figure 22 and the detailed patterns can also be found for the top 10 countries in terms of S&E degrees in Figure 20.
3.1.2 Doctoral degrees

3.1.2.1 Elements of international comparisons

In 2005, some 100 000 doctoral degrees were conferred in the EU-27, against 53 000 in the US and 15 000 in Japan (Figure 23). From 1998 to 2005 (from 1999 for Japan), the number of doctoral degrees increased respectively by 4.4% per year on average in the EU-27, 2% in the US and 5.7% in Japan. In the US, the number of doctoral degrees tended to decrease from the period between 1998 and 1999 to 2002, and then increased. In the EU-27 and the US, the growth of doctoral degrees is lower than for tertiary degrees with academic orientation.

The share of science and engineering fields is relatively similar in the 3 areas, 40% in the EU-27, 36% in the US and 38% in Japan. This share decreased in the EU-27 from 1998 to 2005.
(nearly -4 percentage points). It decreased in the US from 1998 to 2002 and then increased slightly (except for 2004\textsuperscript{23}). In Japan, it tended to decrease very slightly as well.

Figure 23. Number of doctoral degrees and share of S&E fields, in the EU-27, US and Japan (1998-2005)

Source: JRC-IPTS with Eurostat data.

The number of science doctoral degrees conferred in the EU-27 increased by 2.7% per year on average between 1998 and 2005. In the US it slightly increased by 0.8% per year from 1998 to 2005 (it decreased from 1998 to 2002 and then increased\textsuperscript{24}) and in Japan it increased by 6.9% per year.

In engineering, the number of doctoral degrees increased by 3.8% per year in the EU-27, 1% in the US (with a similar pattern: decreasing from 1998 to 2002 and then increasing) and 3.2% in Japan.

In 2005, the share of doctoral degrees in science fields in the total number of doctoral degrees was the highest in the EU-27 (27%, against 23% in the US and 16% in Japan; Figure 24). The share of engineering fields is relatively similar in the EU-27 and US (around 13%) while it is higher in Japan (22%).

In the EU-27, the share of science fields in the total number of doctoral degrees decreased regularly over the period 1998 to 2005 (-3 percentage points), while the share of engineering was relatively stable. In the US, the share of science fields decreased slightly and the share of engineering was more or less stable. In Japan, the share of science fields increased very slightly while the share of engineering fields decreased.

\textsuperscript{23} This strong drop may be explained by a problem in the data collected.

\textsuperscript{24} Except for the surprising drop of 2004 (see footnote above).
3.1.2.2 EU-27 level

The number of doctoral degrees conferred in the EU-27 increased on average by 4.4% per year between 1998 and 2005 (+26,000 degrees) (Cf. Figure 25 and Table 8), less than the growth observed for second degrees with academic orientation. It increased in all fields, but the highest growth is found in services (+10.2% p.a.) and teacher training and education sciences (+10.2% p.a.).

In science, mathematics and computing, the number of doctoral degrees increased by 2.7% per year on average (+4,600 degrees). In engineering, manufacturing and construction, the increase was one of 3.8% per year (+3,100 degrees).

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25 This growth may be slightly overestimated as data for Romania are only available from 2003. In addition, the 2005 data for Italy were not available when the calculations were made (November 2007). Instead, 2004 data were used for this country.
### Table 8. Number of doctoral degrees conferred in the EU-27, by main fields (1998 and 2005)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher training and education science</td>
<td>1,506</td>
<td>2,971</td>
<td>Variation: 1,465, Growth rate: 97.3%</td>
</tr>
<tr>
<td>Humanities and arts</td>
<td>8,351</td>
<td>12,539</td>
<td>Variation: 4,188, Growth rate: 50.1%</td>
</tr>
<tr>
<td>Social sciences, business and law</td>
<td>12,095</td>
<td>17,926</td>
<td>Variation: 5,831, Growth rate: 48.2%</td>
</tr>
<tr>
<td>Science, mathematics and computing</td>
<td>22,826</td>
<td>27,450</td>
<td>Variation: 4,624, Growth rate: 20.3%</td>
</tr>
<tr>
<td>Engineering, manufacturing and construction</td>
<td>10,321</td>
<td>13,395</td>
<td>Variation: 3,074, Growth rate: 29.8%</td>
</tr>
<tr>
<td>Agriculture and veterinary</td>
<td>3,285</td>
<td>3,975</td>
<td>Variation: 690, Growth rate: 21.0%</td>
</tr>
<tr>
<td>Health and welfare</td>
<td>15,886</td>
<td>21,584</td>
<td>Variation: 5,698, Growth rate: 35.9%</td>
</tr>
<tr>
<td>Services</td>
<td>530</td>
<td>1,048</td>
<td>Variation: 518, Growth rate: 97.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>74,800</td>
<td>100,888</td>
<td>Variation: 26,088, Growth rate: 34.9%</td>
</tr>
<tr>
<td><strong>Unknown or not specified</strong></td>
<td>124</td>
<td>257</td>
<td>Variation: 133, Growth rate: 107.3%</td>
</tr>
<tr>
<td><strong>Total with unknown or not specified</strong></td>
<td>74,924</td>
<td>101,145</td>
<td>Variation: 26,221, Growth rate: 35.0%</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS with Eurostat data.

The evolution of the shares of degrees by field in the total number of degrees conferred reflects these developments. The share of science, mathematics and computing doctoral degrees decreased from 30.5% in 1998 to 27.2% in 2005. However, the share of science, mathematics and computing remains far higher compared to the tertiary degrees with academic orientation (10.3%). In engineering, manufacturing and construction, the shares decreased slightly from 13.8% in 1998 to 13.3% in 2005. The share of all the other fields (except the agriculture and veterinary fields) increased.

### Figure 25. Number of doctoral degrees in the EU-27, by fields (1998-2005)

Source: JRC-IPTS with Eurostat data.
3.1.2.3 Evolution by country

All fields

Germany, the UK, France, Italy, Spain and Poland rank top in the number of doctoral degrees conferred in 2005 (Figure 26). These 6 countries accounted for about 72% of the EU-27 total. Among these 6 countries, Italy, Poland and the UK experienced the strongest growth over the period 1998 to 2005, with average annual growth rates of more than 5%. In the UK, the number of doctoral degrees regularly increased between 1998 and 2005 from 11 000 to 15 800. In Italy, the number of doctoral degrees fluctuated between 3 500 and 4 500 between 1998 and 2002, and then increased sharply (6 400 in 2003 and 8 500 in 2004). In Poland, the increase is quite regular as well, from 3 500 in 1998 to 5 700 in 2005.

In contrast, France experienced a slight decrease in its number of doctoral degrees. In Spain, the number of doctoral degrees shows a positive trend from 1998 to 2004, attaining the highest level of 8 200, and then declined in 2005 (6 900). In Germany, the number of doctoral degrees fluctuated, from around 23 000 to 26 000 for the same period.

**Figure 26. Doctoral degrees: number in 2005 and average annual growth rate over the period 1998 to 2005, by country**

In science and engineering (grouping together the two fields 'science, mathematics and computing' and 'engineering, manufacturing and construction'), 3 countries conferred more than 5 000 doctoral degrees each in 2005: Germany, the UK and France. The 3 following top countries, Italy, Spain and Poland, delivered between 1 800 and 3 900 doctoral degrees in these fields. These six countries accounted for about 73% of the EU-27 total. The exception is

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Portugal, which delivered 1,700 doctoral degrees; all the other countries conferred less than 1,500 degrees.

Four countries experienced a decrease in the number of doctoral degrees granted between 1998 and 2005 (Hungary, France, Sweden and Germany). In contrast, the highest growth was observed in Italy, Estonia, Latvia, the Czech Republic, Lithuania, Portugal and Slovakia (with average annual growth rates higher than 10%).

**Figure 27. Doctoral degrees in S&E: numbers in 2005 and average annual growth rate over the period 1998 to 2005, by country**

In science, mathematics and computing, Germany, the UK and France rank top in the number of doctoral degrees granted in 2005, with 6,700, 5,000 and 4,400 degrees conferred respectively (Figure 28). The following three top countries are Italy, Spain and Portugal. These 6 countries accounted for about 78% of the EU-27 total.

Four countries show a decrease in the number of doctoral degrees conferred between 1998 and 2005: Germany, France, Sweden and Hungary. In Germany, this number has tended to decrease, with some fluctuations, between 1998 (7,300) and 2004 (6,000), before increasing in 2005 (6,700). In France, it was relatively stable over the period 1998 to 2001 and seems to have decreased since then. In the UK, the upward trend observed from 1998 (3,800 degrees) to 2003 (5,300 degrees) was checked in 2004 (4,800), before slightly increasing in 2005 (5,000). In Italy, strong growth was observed, particularly in the last 3 years (from 700 in 1998 to 2,300 in 2004). In Spain, the stability observed from 1998 to 2001 (around 1,800 degrees each year) was followed by an increase in 2004 (4,800), before slightly increasing in 2005 (5,000). In Portugal, the number of doctoral degrees was stable from 1998 to 2001 (400 to 450 degrees each year), increased slightly in 2002 and 2003 (650 degrees) and then strongly increased in 2004 and 2005, where 1,100 degrees were conferred that year.


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26 Cf. also the detailed patterns over the period 1998 to 2005 in Figure 30.

27 The data are not complete however.
In engineering, manufacturing and construction, Germany, the UK, Italy, France, Poland and Spain rank top for the number of doctoral degrees conferred in 2005 (Figure 29). These six countries accounted for about 64% of the EU-27 total. The number of degrees in these fields decreased in France between 1998 and 2005, slightly increased in Germany and the UK, and increased more strongly in Spain, Poland and Italy (Cf. also Figure 30). Two other countries saw the number of their degrees decreased, Hungary and Sweden (however, with quasi-stability for this last country).
Figure 30. Number of S&E doctoral degrees and share among the total number of doctoral degrees: evolution from 1998 to 2005, top 10 EU countries

Source: JRC-IPTS based on Eurostat data.
Share of S&E fields

The share of doctoral degrees in science and engineering in the total number of doctoral degrees was the highest in Greece (62%), Cyprus (60%), Ireland (57%) and France (56%) in 2005 (Figure 31). Of the other countries, 3 are above 50% (Latvia, the Czech Republic and Belgium). Looking at science on the one hand and engineering on the other, the ranking of countries is different. For science, mathematics and computing, the same 4 countries rank top (Cyprus, France, Ireland and Greece), with shares of between 41% and 60%. In engineering, manufacturing and construction, Latvia, the Czech Republic, Slovakia and Sweden rank top (between 23% and 34%).

In 17 countries, the share of science doctoral degrees is higher than the share of engineering doctoral degrees. The difference is particularly marked in France (46% in science, 10% in engineering) and Ireland (44% in science, 12% in engineering). The evolution of the share of science and engineering fields by country are displayed in Figure 32.

Figure 31. Share of S&E doctoral degrees in the total number of doctoral degrees in 2005, by country (%)

Source: JRC-IPTS based on Eurostat data.
Figure 32. Evolution of the share of S&E doctoral degrees in the total number of doctoral degrees between 1998 and 2005, by country (%) 

3.1.3 Comparative evolution of tertiary degrees with academic orientation and doctoral degrees over the period 1998 to 2005

The ratio of doctoral degrees to tertiary degrees with academic orientation has tended to decrease slightly over the period 1998 to 2005 (Figure 33). The different paces of evolution of the number of degrees at the two levels, generally lower at the doctoral level, explain the evolution of this ratio. On average, doctoral degrees accounted for 3.9% of tertiary degrees with academic orientation in 1998 and 3.3% in 2005. The decrease is the highest in science, mathematics and computing, from 11.8% in 1998 to 8.9% in 2005.

28 This ratio is indeed explained by the relative evolution at the two levels, which can be approximated as the difference between the two growth rates. Suppose $X_0$ and $X_t$ are the numbers of tertiary degrees with academic orientation at time 0 and time $t$, and that $Y_0$ and $Y_t$ are the numbers of doctoral degrees at time 0 and time $t$. The ratios we calculate are $r_0 = \frac{Y_0}{X_0}$ and $r_t = \frac{Y_t}{X_t}$. Calling $x$ and $y$ the growth rates between 0 and $t$ for each level, $r_t$ can be rewritten as: $r_t = \frac{Y_0(1+y)}{X_0(1+x)} = r_0 \left( \frac{1+y}{1+x} \right) \approx r_0(y-x)$ (the approximation is true for $x$ and $y$ “sufficiently small”).

Source: JRC-IPTS based on Eurostat data.
To study more precisely what is at stake in the field of science, mathematics and computing, we calculated this ratio for each country and for each year. This ratio is given for 1998 and 2005 in the following Figure. It appears that for most countries, this ratio has tended to decrease between 1998 and 2005. It means that the growth in the number of tertiary degrees with academic orientation has been faster than the growth in the number of doctoral degrees between these two years.
However, only two points in time are taken into account in the previous graph, which hides the evolution between 1998 and 2005. Therefore we provide the profiles of this ratio from 1998 to 2005 in Figure 35 for Germany, the UK, France, Italy, Spain and Poland (the 6 countries that conferred the highest number of tertiary degrees with academic orientation in science, mathematics and computing in 2005). The levels and the profiles are quite different from one country to another.

Germany has the highest ratio of doctoral degrees to tertiary degrees with academic orientation and this ratio has been decreasing since 2000. This is the consequence of the strong growth observed in the number of tertiary degrees with academic orientation and the stability and then slight growth of the doctoral degrees. In the UK, the ratio has tended to decrease but with some fluctuations, and it has been on the increase since 2003. In France, the ratio has tended to decrease but seems to have been stable in 2003 and 2005. In Italy, the ratio has increased from 1998 to 2004, which reflects the strong growth of the number of doctoral degrees (which has been stronger than the growth of the number of tertiary degrees with academic orientation). In Spain, the ratio has slightly increased (with fluctuations) over the period, but at both levels, the number of degrees has been relatively stable. In Poland, the ratio has decreased; this is largely explained by the strong growth in the number of tertiary degrees with academic orientation.
3.1.4 Gender differences

The percentage of females earning doctoral degrees in the EU-27 increased from 37% in 1998 to 43% in 2005 (Figure 36). However, a stabilisation was observed in the end of the period, from 2003 to 2005. In all the fields except services, an increase was observed, but important differences by fields remain. Indeed, in engineering, only 22% of doctoral degrees were earned by females, whereas this is the case in 62% of doctoral degrees in teacher training and education science. Females accounted for more than 50% of doctoral degrees in this field, as well as in health and welfare, agriculture and veterinary, and humanities and arts. In science, mathematics and computing, the share of females is 38%.

Source: JRC-IPTS based on Eurostat data.
In percentage points, the increase of the share of females from 1998 to 2005 was highest in teacher training and education (+10.6), agriculture and veterinary fields (+8.7) and the social sciences, business and law (+7.2). In contrast, the increase was notably less pronounced in science, mathematics and computing (+4.8) and engineering, manufacturing and construction (+4.1).

In science, mathematics and computing, the share of females taking doctoral degrees ranges from 60% in Lithuania and Romania to 31% in Denmark and Greece (Figure 37). Four other countries have shares of women higher than 50%: Slovakia, Italy, Poland and Portugal. In all countries except Slovenia, Latvia, Hungary, France and Denmark, the share of women was higher in 2005 than in 1998.

Figure 36. Percentages of doctoral degrees conferred to females in the EU-27, by field (1998-2005)

Source: JRC-IPTS with Eurostat data.
In contrast to the doctoral level, females earned more than half (59%) of the tertiary degrees with academic orientation conferred in the EU-27: this is taken on average with all fields considered together, in 2005. Only two fields, science, mathematics and computing, and engineering, manufacturing and construction, had a lower-than-half share of females, 41% and 27% respectively.

Source: JRC-IPTS with Eurostat data.
Methodology of section 3.1: higher education graduates

The data are taken from Eurostat databases on the number of ISCED 5A and 6 graduates, by levels and fields, for the period from 1998 to 2004. Data were extracted at the end of November 2007. Calculations are from JRC-IPTS.

The EU-27 totals for 2005 are estimations. They have been reconstructed based on 2005 data for all countries except Italy, whose data is for 2004. The growth rates calculated over the period 1998 to 2005 at the EU-27 level may be slightly over-estimated, as data for Romania are only available from 2003. Average annual growth rates calculated by country cover the period from 1998 to 2005, except Italy (1998-2004), Belgium (2000-2005) and Cyprus (1999-2005).

The ISCED is a framework for the compilation and presentation of national and international education statistics and indicators, which is maintained by the UNESCO Institute for Statistics. It has been designed to serve as an instrument suitable for assembling, compiling and presenting comparable indicators and statistics of education both within individual countries and internationally. It is a classification both of levels of education and of fields of study.

In the terminology of the ISCED-97 classification, the level ISCED 5 includes tertiary programmes with academic orientation (type A), which are largely theoretically based, and tertiary programmes with occupation orientation (type B), which are typically shorter than type A programmes and geared for entry into the labour market. These more professional degrees (5B) were excluded from the present analysis.

Source: JRC-IPTS with Eurostat data.

More precisely, ISCED 5A programmes 'are largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programmes and professions with high skills requirements […] The minimum cumulative theoretical duration (at tertiary level) is of three years (FTE). The faculty must have advanced research credentials. Completion of a research project or thesis may be involved.' (OECD 1999, p. 23).

ISCED 5B programmes 'are generally more practical/technical/occupationally specific than ISCED 5A programmes. […] They do not prepare students for direct access to advanced research programmes. They have a minimum of two years full-time equivalent duration. The programme content is typically designed to prepare students to enter a particular occupation.' (OECD 1999 p. 23). Qualifications in category 5B are typically shorter than those in 5A and focus on specific occupational skills, geared for entry into the labour market, although some theoretical foundations may be covered in the respective programme. The content of ISCED level 5B programmes is practically oriented/occupationally specific and is mainly designed for participants to acquire the practical skills and know-how needed for employment in a particular occupation or trade or class of occupations or trades.

In some countries, the differentiation between more academic and more professional degrees is not relevant, whereas in others the distinction between the two is clear (cf. Tauch and Rauhvargers, 2002).

The level ISCED 6 'is reserved for tertiary programmes that lead to the award of an advanced research qualification. The programmes are devoted to advanced study and original research. The level requires the submission of a thesis or dissertation of publishable quality that is the product of original research and represents a significant contribution to knowledge. It is not solely based on course-work. It prepares graduates for faculty posts in institutions offering ISCED 5A programmes, as well as research posts in government and industry.' (OECD 1999, p. 23).

ISCED-97 classifies the fields of education into 25 fields and establishes broad groups composed of fields of education having similarities. The following broad groups are used in this section:
1. teacher training and education science 
2. humanities and arts 
3. social sciences, business and law 
4. science, mathematics and computing 
5. engineering, manufacturing and construction 
6. agriculture and veterinary 
7. health and welfare 
8. services 
9. not known or not specified.

In this section, when we refer to 'science' this means group 4 'science, mathematics and computing', which includes the following.

- Life sciences: biology, botany, bacteriology, toxicology, microbiology, zoology, entomology, ornithology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences.

- Physical sciences: astronomy and space sciences, physics, other allied subjects, chemistry, other allied subjects, geology, geophysics, mineralogy, physical anthropology, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, marine science, vulcanology, palaeoecology.

- Mathematics and statistics: mathematics, operations research, numerical analysis, actuarial science, statistics and other allied fields.
- Computing: computer sciences: system design, computer programming, data processing, networks, operating systems — software development only (hardware development should be classified with the engineering fields).

When referring to 'engineering', we mean group 5 'Engineering, manufacturing and construction', which includes the following.

- Engineering and engineering trades: engineering drawing, mechanics, metalwork, electricity, electronics, telecommunications, energy and chemical engineering, vehicle maintenance, surveying.

- Manufacturing and processing: food and drink processing, textiles, clothes, footwear, leather, materials (wood, paper, plastic, glass, etc.), mining and extraction.

- Architecture and building: architecture and town planning: structural architecture, landscape architecture, community planning, cartography; building, construction; civil engineering.

When speaking of 'science and engineering' (S&E), we refer to the two previous groups (4 and 5).

References


3.2 Postdoctoral researchers in the EU

In Europe, information on postdoctorates is scarce and no comprehensive and comparable data at EU level are available. Therefore, in this section we present the results of the estimation of the number of postdoctorates in the life sciences, engineering and the social sciences in the EU, based on the results from two ad hoc surveys commissioned by JRC-IPTS. 30

Constructing indicators on the number of postdoctoral researchers at EU level involves the methodology of combining Eurostat aggregated data and data from the two pilot ad hoc surveys carried out on a sample of EU countries: the NetReAct survey (2005) for the life sciences, and the Rescar survey (2007) for engineering and the social sciences. These surveys collected information on doctoral candidates and postdoctorates in 9 EU countries (the Czech Republic, Germany, Spain, France, Hungary, Italy, Portugal, Sweden and the UK), through questionnaires addressed to the heads of university-based research teams.

Two methods have been used to estimate the number of postdoctorates (see the Methodology Section for more details). The first one (Method 1) uses only the NetReAct and Rescar surveys and is based on the identification of research teams and the average number of postdocs. The second method (Method 2) combines the NetReAct and Rescar survey and Eurostat data. It is based on the NetReAct and Rescar structure of research teams and the Eurostat number of doctoral candidates. Results based on the second method are likely to be

30 See methodology for more details on sources and methods.
more reliable, the first method being based on two (NetReAct) or three (Rescar) different steps, each step being a potential source of error. The methodology of the second method is likely to limit the uncertainty as it is partly based on Eurostat data and not only on the results of the surveys.

3.2.1 Life sciences and engineering

In the life sciences and engineering, the total numbers of postdocs in the EU-27 given using the two methods are relatively similar.

In the life sciences, there would be about 22,000 postdocs according to the first method, and about 25,000 according to the second method.

In engineering, the first method results in 37,000 postdoctoral researchers against 43,000 for the second method.

In the life sciences, we found that the highest number of postdoctoral researchers is in the UK (5,700 with Method 1 and 5,900 with Method 2). The ranking of countries is about the same using both methods of calculation. As already mentioned, the first method ranks the UK first. It is followed by France (2,800) and Germany (2,700). The three top countries using the second method are the UK, Germany (4,200) and France (3,500).

In engineering, with Method 1, we find that the number of postdocs is the highest in Spain (about 6,100), followed by Germany (5,200) and the UK (4,200). With Method 2, Spain has the highest number of postdocs by far (about 10,000), followed by Italy (5,000) and the UK (4,700).

3.2.2 Social sciences

In the social sciences, there are about 54,000 postdoctoral researchers when following the first method, and about 83,000 when following the second method.

With Method 1, the highest numbers of postdocs are found in Germany (8,700), Spain (8,600) and the UK (7,800). With Method 2, the ranking of countries is about the same (but the numbers differ greatly, except for the UK), with Germany (20,000), Spain (13,200) and the UK (8,300) ranking top.
Figure 39. Estimated number of postdoctoral researchers in life sciences, engineering and social sciences in the EU-27 (2004)

Table 9. Estimated number of postdoctoral researchers in the life sciences, engineering and the social sciences, in 9 EU countries, according to Methods 1 and 2

<table>
<thead>
<tr>
<th></th>
<th>Method 1</th>
<th>Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Life sciences</td>
<td>Engineering</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>415</td>
<td>1 599</td>
</tr>
<tr>
<td>Germany</td>
<td>2 749</td>
<td>5 189</td>
</tr>
<tr>
<td>Spain</td>
<td>1 613</td>
<td>6 098</td>
</tr>
<tr>
<td>France</td>
<td>2 768</td>
<td>3 125</td>
</tr>
<tr>
<td>Hungary</td>
<td>364</td>
<td>368</td>
</tr>
<tr>
<td>Italy</td>
<td>2 094</td>
<td>3 897</td>
</tr>
<tr>
<td>Portugal</td>
<td>573</td>
<td>1 078</td>
</tr>
<tr>
<td>Sweden</td>
<td>910</td>
<td>510</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5 717</td>
<td>4 205</td>
</tr>
<tr>
<td><strong>EU-27</strong></td>
<td><strong>22 262</strong></td>
<td><strong>37 290</strong></td>
</tr>
</tbody>
</table>

Source: JRC-IPTS. See text for details.

3.2.3 Assessment of results

Calculating the number of postdoctoral researchers is therefore problematic, especially in the social sciences (for more details on the statistical analysis of differences between the two
methods, please see the Methodology section). There are various explanations, set out below, used in attempting to explain the difficulties in estimations.

- In the Rescar survey, the response rate was low (13%).

- The definition of the social sciences may be loose, compared to natural sciences and engineering, and subject to various interpretations in different data sources.

- The identification of departments and teams is uncertain, and probably more difficult in the social sciences than in engineering.

- There is some uncertainty concerning the number of doctoral candidates calculated with Eurostat data, particularly for Germany, for which no data are given by Eurostat.

- In the two surveys, the definition of postdoctorate was not specified, and was left to the interpretation of the heads of unit. There is no agreement on the definition of postdoctorate, except that it is a 'temporary' research position, generally based in the academic sector. National and disciplinary traditions may vary considerably in that respect. If the term postdoc may appear particularly obvious — in some disciplines, notably in the life sciences, and in some countries, notably in the UK — it is likely to lead to different interpretations in many countries and many disciplines, and particularly in the social sciences. In the frame of the NetReAct and Rescar surveys, postdoctorates may be assimilated with non-tenured, non-permanent academic positions.

The extrapolation performed at EU-27 level is likely to be valid as the number of doctoral graduates in the 9 countries under consideration account for 77% of the EU-27 total in the life sciences, 70% in engineering and 76% in the social sciences.

However, the results calculated here are broad estimations of the number of postdoctoral researchers in the EU-27. They have to be interpreted with caution as they are based on the results of surveys, with a limited number of observations. Large margins of error are likely to exist around the point estimates given here. This is particularly the case for the social sciences.

More precise and detailed results would require other types of data, such as cohort data, the collection of which is very costly in terms of time and money. Such data only exist in very few countries (notably in some Nordic European countries).
Methodology of section 3.2: postdoctoral researchers

Data

The research population identified by the NetReAct project\(^{31}\) consists of 7,732 teams working in the life sciences, from 359 universities. Strata for sampling were grouped according to country, and a simple importance indicator was derived from the webometrics analysis. Overall, 1,773 teams were selected for the sample. After sampling and eliminating the unusable responses, the number of usable questionnaires in the sample comprised 468 teams, which corresponds to 26% of the respondents included in the sample.

The Rescar survey\(^{32}\) identified a universe of 5,500 university departments in the social sciences and engineering from 539 universities. A sample of 1,200 departments was drawn using random stratified sampling. In this sample, 4,700 teams were identified and approached. A questionnaire was implemented and sent to the heads of units of these research teams; 595 valid questionnaires were completed, giving a lower-than-expected response rate of 13%.

Method 1

The first method involves estimating the number of postdocs using only the survey results (NetReAct on the one hand, Rescar on the other). Only the EU extrapolation depends on external data (Eurostat). The method is slightly different for the life sciences and for the social sciences and engineering.

Postdocs in life sciences

The number of postdocs in the country \(i\) can be broken down as:

\[
\hat{N}_i^p = T_i \hat{P}_i
\]

where \(T_i\) is the NetReAct number of the life sciences teams identified in country \(i\) and \(P_i\) is the NetReAct estimated average number of postdoctorates per team in the country \(i\).

\(P_i\) has been estimated on a sample of \(n_i\) teams, each team \(l\) in the country \(i\) having an estimated number of postdoctorates \(p_{il}\):

\[
\hat{P}_i = \frac{1}{n_i} \sum_{l=1}^{n_i} \hat{p}_{il}
\]

The total number of postdocs in the EU-27 is then extrapolated based on an inflation factor:

---


The inflation factor is the ratio of the number of doctoral candidates in the 9 countries to the total number of doctoral candidates in the 27 countries\(^{33}\), estimated with Eurostat data:

$$f = \frac{\sum_{i=1}^{27} N_i^C}{\sum_{i=1}^{27} \hat{N}_i^C}$$

Postdocs in engineering and social sciences

Compared to the method used for the life sciences, a supplementary step is necessary. Indeed, in contrast to the NetReAct survey, the universe of teams has not been identified in the Rescar survey, only the universe of university departments. Therefore, it is necessary to first calculate the number of teams in each field which can be estimated as the product of the number of departments in each field identified (in the universe) and the average number of teams per department in each field (estimated from the sample).

Using the same expressions as before, \(T_i\) the number of teams identified in country \(i\), has now to be broken down as:

$$\hat{T}_i = N_D \hat{a}_i$$

Where \(N_D\) is the number of departments in engineering/social sciences and \(a_i\) is the average number of teams per department (estimated from the sample), in the country \(i\).

Once we have the total number of teams by country, we calculate the total number of postdocs by country, in a similar way as for the life sciences, by multiplying it by the average number of postdocs per team, and similarly we extrapolate the results at EU-27 level.

Method 2

The second method combines NetReAct/Rescar survey results and Eurostat data. More precisely, it is based on the structure of research teams calculated using the NetReAct/Rescar survey and the number of doctoral candidates estimated with Eurostat data. The number of postdocs is calculated as the product of the number of doctoral candidates and the average ratio of postdoctorates to doctoral candidates per team.

More precisely, the number of postdocs in each field in the country \(i\) is calculated as the product of the number of doctoral candidates in the country \(i\) and the ratio of the NetReAct/Rescar estimated average number of postdoctorates per team in the country \(i\) to the NetReAct/Rescar estimated average number of doctoral candidates per team in the country \(i\). The average number of postdoctorates (as above) and

---

\(^{33}\) The implicit assumption behind this factor is that the share of the 9 countries in the EU-27 total is equal for doctoral candidates and postdoctorates.
the average number of doctoral candidates per team in each field by country has been estimated on a sample of ni teams with the NetReAct/Rescar data.

Formally, the number of postdocs in the country i is calculated as follows:

$$\hat{N}_i^{*p} = \hat{r}_i N_i^C$$

Where $$\hat{r}_i = \frac{\hat{P}_i}{\hat{C}_i}$$ is the ratio of the NetReAct/Rescar estimated average number of postdoctorates per team in the country i ($$\hat{P}_i$$) to the NetReAct/Rescar estimated average number of doctoral candidates per team in the country i ($$\hat{C}_i$$).

$$\hat{P}_i$$ is defined as above and $$\hat{C}_i$$ is defined similarly as:

$$\hat{C}_i = \frac{1}{n_i} \sum_{l=1}^{n_i} \hat{C}_{il}$$

The total number of postdocs in the EU-27 is then extrapolated in the same way as before with an inflation factor:

$$\hat{N}_{EU27}^{*p} = \frac{\sum_{i \in D} \hat{N}_i^{*p}}{f}$$

with D = (CZ, DE, ES, FR, HU, IT, PT, SE, UK).

**Comparisons of the two methods**

In the life sciences, the difference in the total number of postdocs in the EU-27 using Methods 1 and 2 is 13.6%. The highest discrepancy in absolute terms is found for Germany, the first method giving a number of postdocs of about 2 700 and the second method 4 000.

For the engineering field, the difference between Method 1 and 2 is about 15%. The highest difference in absolute terms is observed for Spain (the first method gives 6 100 postdocs and the second 10 300), far greater than the other country differences.

For the social sciences, the differences between Methods 1 and 2 are far higher than for the life sciences and engineering. The first method gives a total number of postdocs in the EU-27 of about 54 000 while the second method gives 83 000, 54% more. For all 9 countries, the second method gives a higher number of postdocs than the first method, contrary to the life sciences and engineering where no systematic bias was found. In absolute terms, the highest discrepancies are found in Germany (a difference of 11 200), for which the second method gives a number of postdocs more than double the one calculated with the first method, 19 900 against 8 700, and Spain (a difference of 4 600) with 13 200 using the first method and 8 600 using the second.
These discrepancies can be explained by the differences in calculation Methods 1 and 2. If we compute the following statistics, which is the modulus of the difference for each country:

$$d_i^m = |N_i^P - N_i^M|$$

(where $N_i^P$ and $N_i^M$ are respectively the number of postdocs estimated with Method 1 and 2)

and divide it by the sum, i.e. $\frac{\sum d_i^m}{\sum_j d_j^m}$, we find that:

- For the life sciences, Germany alone explains 36% of the total discrepancy, followed by France with 20% and Sweden with 11%.

- For engineering, results for Spain explain 36% of the total discrepancy calculated in modulus, followed by Germany (16%) and France (14%).

- For the social sciences, results for Germany explain half of the sum of differences calculated in modulus, followed by Spain (21%) and Portugal (9%).

Table 10. Number of postdoctorates in the life sciences: differences in modulus between Methods 1 and 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Differences in modulus ($d_i^m$)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech Republic</td>
<td>302</td>
<td>8%</td>
</tr>
<tr>
<td>Germany</td>
<td>1 294</td>
<td>36%</td>
</tr>
<tr>
<td>Spain</td>
<td>293</td>
<td>8%</td>
</tr>
<tr>
<td>France</td>
<td>726</td>
<td>20%</td>
</tr>
<tr>
<td>Hungary</td>
<td>156</td>
<td>4%</td>
</tr>
<tr>
<td>Italy</td>
<td>184</td>
<td>5%</td>
</tr>
<tr>
<td>Portugal</td>
<td>46</td>
<td>1%</td>
</tr>
<tr>
<td>Sweden</td>
<td>413</td>
<td>12%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>161</td>
<td>5%</td>
</tr>
<tr>
<td>All 9 countries</td>
<td>3 574</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS.

---

34 For the life sciences, this can also be attributed to the evolution of the number of postdocs between 2003 and 2004. With the second method, we used data on the number of doctoral candidates in 2004, contrary to the first method that corresponds to 2003. Indeed, with the first method, it is not possible to estimate the situation in 2004, as NetReAct provides the structure of research teams in 2003.
Table 11. Number of postdoctorates in engineering and the social sciences: differences in modulus between Methods 1 and 2

<table>
<thead>
<tr>
<th></th>
<th>Engineering</th>
<th></th>
<th>Social sciences</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference in modulus ( $d_i^m$ )</td>
<td>%</td>
<td>Difference in modulus ( $d_i^m$ )</td>
<td>%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1 505</td>
<td>13%</td>
<td>1 429</td>
<td>6%</td>
</tr>
<tr>
<td>Germany</td>
<td>1 880</td>
<td>16%</td>
<td>11 206</td>
<td>51%</td>
</tr>
<tr>
<td>Spain</td>
<td>4 233</td>
<td>16%</td>
<td>4 635</td>
<td>21%</td>
</tr>
<tr>
<td>France</td>
<td>1 650</td>
<td>14%</td>
<td>1 270</td>
<td>6%</td>
</tr>
<tr>
<td>Hungary</td>
<td>15</td>
<td>0%</td>
<td>273</td>
<td>1%</td>
</tr>
<tr>
<td>Italy</td>
<td>1 113</td>
<td>10%</td>
<td>166</td>
<td>1%</td>
</tr>
<tr>
<td>Portugal</td>
<td>314</td>
<td>3%</td>
<td>1 879</td>
<td>9%</td>
</tr>
<tr>
<td>Sweden</td>
<td>459</td>
<td>4%</td>
<td>763</td>
<td>3%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>490</td>
<td>4%</td>
<td>404</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>11 658</strong></td>
<td><strong>100%</strong></td>
<td><strong>22 025</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: JRC-IPTS.
4 International mobility of researchers within, into and out of the European Union

Sections 5.1 will present results on the international mobility of researchers within and into the EU. Section 5.2 will analyse the international mobility out of the EU.

4.1 International mobility within and into the EU

Section 5.1.1 will present the origin of doctoral candidates in all fields. Section 5.1.2 will develop the origin of doctoral candidates and postdoctoral researchers in the EU in three fields (life sciences, social sciences, engineering) based on the results of two ad-hoc surveys. Section 5.1.3 will analyse the researchers by citizenship. Section 5.1.4 will study the recent evolution of Human Resources for Science and Technology Core by citizenship and country of birth.

4.1.1 Doctoral candidates in the EU in all fields

4.1.1.1 Origin of doctoral candidates: overall picture

In the European Union (based on 21 EU countries having reported data to Eurostat)\(^{35}\), in 2005, among the 487,000 doctoral candidates, 79.5% were citizens of the country in which they work, 5.8% had the nationality of another Member State (accounting for about 28,000 doctoral candidates) and 14.1% came from third countries: 5.3% were from Asia, the Middle East and Oceania, 3.7% from Africa, 3.1% from South and central America, 1.1% from other European countries (outside the EU-27) and 0.9% from North America. 0.5% were of unknown citizenships (cf. Figure 40)\(^{36}\).

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\(^{35}\) The six missing countries are Germany, Ireland, Greece, Latvia, Luxembourg and the Netherlands.

\(^{36}\) Considering the nationality breakdown of the total EU working age population, one finds that third country nationals account for 3.4% and other EU-25 nationals account for 1.5%. Only Belgium, Ireland and Luxembourg have a higher share of EU-25 nationals (respectively 4.7%, 4.6% and 33.1%) than third country nationals (2.8%, 2.7% and 3.2%).
4.1.1.2 Intra-EU inflows and outflows

The number and percentage of doctoral candidates holding citizenship of another Member State is given in Figure 41 for each of the 21 countries reporting data.

The UK had the highest number of doctoral candidates of EU origin, some 11 500, in 2005. It is followed by France (5 400) and Spain (3 100). These three countries accounted for about 70% of the 28 000 doctoral candidates holding citizenship of another Member State (40% alone for the UK). No other single country had more than 2 000 doctoral candidates holding the nationality of another Member State.

As share of the total number of doctoral candidates of the reporting country, the UK, Austria and Belgium were the 3 top countries, having 12.5%, 12.5% and 12.1% respectively of their doctoral candidates with citizenship of another EU country. The following top countries are Cyprus, Sweden, France, Denmark and Hungary, with shares between 5% and 10%. In the remaining 13 countries (out of 21), foreign EU candidates accounted for less than 5% of enrolments at doctoral level.
Figure 41. Number and percentage of doctoral candidates with the citizenship of another EU Member State in the reporting country (2005)

For a given nationality, the number of doctoral candidates abroad is calculated by adding up the numbers provided for this nationality by the 21 receiving EU countries for which data are available.

To get a picture of the situation in relative terms, it is then possible to divide these numbers by 37:

- The total number of doctoral candidates in the considered country. It can be interpreted as the outflow of doctoral candidates of a given nationality relative to the size of the total population of doctoral candidates in the corresponding country.

- The total number of doctoral candidates of this nationality, including those within the home country. It can be interpreted as the relative mobility of doctoral candidates of a given nationality.

Results are presented in the following figure.

In absolute terms, we find that 4 000 Greeks, 3 900 Germans and 3 600 Italians are pursuing doctoral studies in a Member State other than their country of citizenship. The following top nationalities are Portuguese, Romanian and French.

37 The two ratios provide very similar results as they differ only in the share of doctoral candidates from outside the EU.
The ratio of the number of expatriates’ doctoral candidates in the 21 EU countries reporting data to the total number of doctoral candidates in the considered country (first ratio) is the highest for Ireland (25.7%), Greece (17.8%), Slovenia (14.8%) and Portugal (13%)\(^{38}\). It is the lowest (below 3%) in the UK, the Czech Republic, Finland, Sweden, Austria, Spain and France.

The percentage of doctoral candidates continuing their doctoral education in a EU country other than their country of citizenship (second ratio) is highest in Slovenia (13.5%), Bulgaria (12.5%), Portugal (12.4%) and Estonia (11%). It is lowest (below 3.5%) for the UK, the Czech Republic, Finland, Sweden, Spain, Austria, France and Poland.

**Figure 42. Number and percentage of doctoral candidates of the reporting nationality in all the other Member States (2005)**

Source: JRC-IPTS. Eurostat data. Number: 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. Share 1: the number is divided by the total number of doctoral candidates in the considered country whatever their nationality (it was not possible to calculate this ratio for Germany and Luxembourg which do not provide the total number of doctoral candidates). Share 2: the number is divided by the total number of doctoral candidates of this nationality including those within the home country (it was not possible to calculate this ratio, in addition to the two previous countries, for Greece Ireland, Netherlands and Latvia which do not report data by nationality).

The intra-EU net gains have been calculated as the differences between the number of doctoral candidates of EU nationality in the reporting country and the number of its citizens’ doctoral candidates in the other Member States\(^{39}\).

---

\(^{38}\) If we exclude Malta and Cyprus which have very high ratios, 257% and 144% respectively, due to the limited number of doctoral candidates in these two countries.

\(^{39}\) This excludes the nationalities corresponding to countries for which data are not provided, i.e. we worked with a 21x21 matrix.
The UK is the most important intra-EU net gainer, in absolute and relative terms, of the intra-EU exchanges of doctoral candidates, with a net gain of 5 300 doctoral candidates, accounting for 5.8% of the total number of doctoral candidates in the UK.

The other countries with a positive intra-EU net gain are France, Spain, Austria, Sweden, the Czech Republic, Finland and Belgium, accounting for between 0.9% (in Finland) and 4.9% (in Austria) of their total number of doctoral candidates.

The highest intra-EU net losses in absolute terms are found in Italy, Portugal and Romania, accounting for 8.5%, 11.8% and 8.9% respectively of their number of doctoral candidates.

Figure 43. Intra-EU 'net gain' of doctoral candidates: differences between the number of doctoral candidates of EU nationality in the reporting country and the number of its citizens' doctoral candidates in other Member States (2005)

Source: JRC-IPTS with Eurostat data. The net loss in % is not represented on the figure, as it is 143% for Cyprus and 257% for Malta.

4.1.1.3 Doctoral candidates from third countries

The top 30 countries of origin of doctoral candidates in the 21 EU countries having reported data are given in Figure 44. These 30 top citizenships account for 74% of doctoral candidates from third countries in the EU-21.

Chinese doctoral candidates were the most numerous, about 5 200, accounting for 7.5% of the total number of doctoral candidates from third countries (or 1.1% of the total number of doctoral candidates) in the EU-21. The three top receiving countries of Chinese doctoral candidates were the UK (3 200), France (1 000) and Sweden (360).
Mexico ranks second with some 3,800 doctoral candidates. Mexican doctoral candidates are mainly found in Spain (2,400), the UK (800) and France (500).

Morocco ranks third, with 3,200 doctoral candidates: 2,500 are located in France, 460 in Spain and 110 in Belgium.

The US ranks fourth, with about 3,000 individuals, accounting for about 4.4% of doctoral candidates from third countries (or 0.62% of the total number of doctoral candidates) in the 21 Member States. The three top receiving countries of US citizens were the UK (2,400), France (200) and Spain (200).

**Figure 44. Top 30 countries of origin for foreign doctoral candidates from third countries (2005)**

The three major receiving countries (among the 21 countries reporting data) of doctoral candidates from third countries, were the UK, France and Spain, with 24,100, 23,000 and 11,300 respectively (Figure 45). All three together received 58,400 doctoral candidates from third countries, accounting for 84.8% of the total of 68,900 received by the 21 countries, while the UK, France and Spain account for only 51.4% of the total number of doctoral candidates. The following top countries each received less than 2,000 doctoral candidates from third countries.

As percentage of the total number of doctoral candidates in the reporting country (Figure 46), France, the UK, Belgium and Spain received the highest share, respectively 27.9%, 26.3%, 18.7% and 14.8%. All the other countries were below 10%. The share of North American...
citizens is below 1% in all of the 21 Member States except in the UK, where it was 3.7% (Cf. Table 12).

In the UK, 15 200 doctoral candidates were from Asia, the Middle East or Oceania, the top region of origin, accounting for 16.5% of the total number of doctoral candidates in this country. A total of 3 400 came from North America, accounting for 3.7% of the stock of doctoral candidates: 2 400 were from the US (accounting for about 78% of the total number of doctoral candidates from this country in the 21 Member States reporting data) and 1 000 from Canada (of the 1 350 Canadians in the EU-21)[40]. In the UK, 2 700 doctoral candidates were from Africa, accounting for 3%, 1 900 were from South and Central America, accounting for 2%, and 1.1% from other European countries outside EU.

In France, the top region of origin of doctoral candidates was Africa: 12 500 doctoral candidates were from this region, accounting for 15.1% of the total number of doctoral candidates. Of doctoral candidates, 6 800 are from Asia, the Middle East and Oceania, accounting for 8.2% of doctoral candidates. Here, 2 350 (2.8%) were from South and central America and 1 000 (1.3%) from other European countries outside EU. North America accounts for 427 doctoral candidates (0.5%): 225 from Canada and 200 from the US.

In Spain, the top region of origin is South and central America, with 9 700 doctoral candidates, accounting for 12.7% of doctoral candidates in Spain. The second top region of origin is Africa, with 700 individuals (0.9%). Asia, the Middle East and Oceania rank third, accounting for 470 individuals (0.6%).

Figure 45. Number of non-EU citizen doctoral candidates by receiving Member State, according to citizenship (2005)

Source: JRC-IPTS based on Eurostat data.

[40] See also Table 13.
Figure 46. Number of non-EU citizen doctoral candidates, according to citizenship, as a percentage of the total number of doctoral candidates in receiving Member States (2005)

Source: JRC-IPTS based on Eurostat data.
<table>
<thead>
<tr>
<th>Nationals</th>
<th>EU-27</th>
<th>Other Europe</th>
<th>Africa</th>
<th>North America</th>
<th>South and Central America</th>
<th>Asia, Middle East, Oceania</th>
<th>Unknown</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>69.2</td>
<td>12.1</td>
<td>1.0</td>
<td>9.2</td>
<td>0.6</td>
<td>2.7</td>
<td>5.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>92.5</td>
<td>2.9</td>
<td>1.1</td>
<td>0.6</td>
<td>0.0</td>
<td>0.3</td>
<td>2.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>92.8</td>
<td>3.9</td>
<td>1.0</td>
<td>0.5</td>
<td>0.1</td>
<td>0.2</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>81.5</td>
<td>6.4</td>
<td>1.9</td>
<td>0.3</td>
<td>0.7</td>
<td>0.6</td>
<td>4.0</td>
<td>4.6</td>
</tr>
<tr>
<td>Estonia</td>
<td>97.5</td>
<td>1.6</td>
<td>0.4</td>
<td>0.0</td>
<td>0.2</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Spain</td>
<td>81.1</td>
<td>4.1</td>
<td>0.3</td>
<td>0.9</td>
<td>0.3</td>
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</tr>
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</tr>
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</tr>
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<td>0.5</td>
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</tr>
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<td>0.1</td>
<td>3.2</td>
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</tr>
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<td>0.3</td>
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</tr>
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</tr>
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<td>16.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS with Eurostat data. How to read: 16.5% of doctoral candidates in the UK are from Asia, Middle East and Oceania.
Table 13. Destination of doctoral candidates from each broad region of origin, according to receiving country (%)

<table>
<thead>
<tr>
<th></th>
<th>Nationals</th>
<th>EU-27</th>
<th>Other Europe</th>
<th>Africa</th>
<th>North America</th>
<th>South and Central America</th>
<th>Asia, Middle East, Oceania</th>
<th>Unknown</th>
<th>TOTAL</th>
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<td>1.5</td>
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<td>1.0</td>
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<td>0.5</td>
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<td>0.0</td>
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<td>4.0</td>
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<td>0.1</td>
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<td>0.6</td>
</tr>
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<td>2.6</td>
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<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
<td>1.6</td>
</tr>
<tr>
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</tr>
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<td>3.9</td>
<td>0.3</td>
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<tr>
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</tr>
<tr>
<td>Slovakia</td>
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</tr>
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<td>0.3</td>
<td>1.6</td>
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</tr>
<tr>
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<td>0.9</td>
<td>3.4</td>
<td>43.0</td>
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</tr>
<tr>
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<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: JRC-IPTS with Eurostat data. How to read: 69.6% of doctoral candidates, in the 21 EU countries reporting data, from Africa are located in France.
Methodology of section 4.1.1: doctoral candidates in the EU

Data are from Eurostat. They were extracted on 29 November 2006.

Calculations are based on 21 countries only, as data on the remaining countries are not available. These 21 countries are as follows: Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, Spain, France, Italy, Cyprus, Lithuania, Hungary, Malta, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and the UK. The following are missing: Germany, Ireland, Greece, Latvia, Luxembourg and the Netherlands.

Here, 'mobile'/international' students are defined on the basis of their country of citizenship. The data collected on mobile/international students changed in the Unesco-OECD-Eurostat data collection in 2005\textsuperscript{41}. However, the changes have not been fully implemented yet and cannot be used here, as it is still in the pilot phase, not available for full exploitation. This change has been motivated by the fact that the data collected before the 2005 UOE data collection are not appropriate for measuring all mobile/international students. Observations based on this criterion are affected by the differences in legislation governing the acquisition of nationality. Thus, certain foreign students may have lived in their host countries for many years and completed some or all of their prior education in the same country, and therefore, they may have never been 'mobile'. Citizenship alone is not a variable sufficient to measure incoming and outgoing students. New concepts are introduced in the 2005 UOE data collection to better capture student mobility across countries: country of citizenship, country of permanent residence and country of prior education. This data collection is a pilot collection, not yet fully validated. Therefore, the data are not available yet for full exploitation. This pilot may run for the UOE 2008 data collection as well. There is no common definition of 'residence status' across EU countries. Therefore, another concept is piloted (prior country of education) with a view to get datasets as comparable as possible.

Data on foreign students refer here to citizenship. Students are non-citizen students if they do not have the citizenship of the country for which the data are collected. Normally citizenship corresponds to the nationality of the passport which the student holds or would hold. Countries unable to provide data or estimates for non-citizens on the basis of the passport held should fill other parts of the data collection on mobile/international students depending on the concept available in their data sources (country of permanent or usual residence, country of prior education).

References:


4.1.2 Origin of doctoral candidates and postdoctoral researchers in the EU in three fields (life sciences, social sciences, engineering)

4.1.2.1 Doctoral candidates

As in Eurostat data, the number of doctoral candidates by nationality is not disaggregated by fields, we have constructed indicators using the two pilot ad hoc surveys commissioned by JRC-IPTS. As for section 3.2 on the number of postdoctorates, the methodology entails combining Eurostat aggregated data and data from the two pilot ad hoc surveys carried out on a sample of EU countries, the NetReAct survey (2005) (for the life sciences), and the Rescar survey (2007) (for engineering and the social sciences).

In the NetReAct and Rescar surveys, information on the origin of doctoral candidates is available. To have an EU picture of the origin of doctoral candidates in the life sciences, the social sciences and engineering, we apply the following method (see the Methodology section for more details). First, we extract the distribution of doctoral candidates by country of origin from the NetReAct and Rescar surveys. Second, we apply these percentages to the number of doctoral candidates from Eurostat data, we calculate the sum for the 9 countries and we extrapolate the results to the EU-27 level. The same method is applied separately for each field (life sciences, social sciences and engineering). Results are shown in the following graph.

We found that 75% of doctoral candidates in the life sciences, 69% of doctoral candidates in engineering, and 75% of doctoral candidates in the social sciences in the EU-27 undertake doctoral studies in their country of origin. Therefore, 25% of doctoral candidates in the life sciences, 31% in engineering, and 25% in the social sciences are of foreign origin. That can be broken down as follows: 9% in the life sciences (8% in engineering and 7% in the social sciences respectively) from other EU countries ('intra-EU'), and 16% in the life sciences (23% in engineering and 18% in the social sciences respectively) from third countries ('extra-EU').

42 Please, see this section for more details.
4.1.2.2 Postdoctorates

In Europe, information on postdoctorates is scarce and no comprehensive and comparable data at the EU level are available. Therefore, in this section we present the results of the estimation of the origin of postdoctorates in the life sciences, engineering and the social sciences, based on the results of the two similar ad hoc pilot surveys (see above and section 3.2).

Based on the estimated number of postdoctorates (see section 3.2) and on the information provided in the NetReAct and Rescar surveys on the origin of postdoctorates, we can estimate the origin of postdoctorates in the life sciences, engineering and the social sciences in the EU-27. We have followed a similar methodology as above (origin of doctoral candidates in three fields). First, we extracted the distribution of postdoctorates by country of origin from the NetReAct and Rescar surveys. Second, we applied these percentages to the number of postdoctorates previously calculated for indicator 2. Third, we calculated the sum for the 9 countries and we extrapolated the results at EU-27 level. Results are given in the following graph.

We found that 58% of postdoctorates in the life sciences, 72% of postdoctorates in engineering and 78% of postdoctorates in the social sciences work in their country of origin. Therefore, 42% of postdocs in the life sciences, 28% in engineering and 22% in the social sciences are of foreign origin. That can be broken down as follows: 18% in the life sciences (11% in engineering and 9% in the social sciences respectively) from other EU countries

We have provided the results for the second method only as the results of this method are likely to be more reliable. In addition, the results in percentages are close for the two methods.

Source: JRC-IPTS based on Eurostat data and, NetReAct and Rescar surveys.
('intra-EU') and 24% in the life sciences (18% in engineering and 13% in the social sciences respectively) from third countries ('extra-EU').

**Figure 48. Percentage of postdoctoral researchers in the EU-27 according to their country of origin, in life sciences, engineering and social sciences (2004)**

Source: JRC-IPTS based on Eurostat data and, NetReAct and Rescar surveys.

**Methodology of section 4.1.2: origin of doctoral candidates and postdoctorates in the EU in three fields**

In the NetReAct and Rescar surveys, information on the origin of doctoral candidates is available (for more details on the surveys, please see section 3.2). To get an EU picture of the origin of doctoral candidates in each of the three fields, we apply the following method.

First, we extract the distribution of doctoral candidates by country of origin from the surveys. Second, we apply these percentages to the number of doctoral candidates from Eurostat data, we calculate the sum for the 9 countries and we extrapolate the results at the EU-27 level. The same method is applied separately for the life sciences, the social sciences and engineering.

More precisely, the number of doctoral candidates in the country i from region m is the product of the percentage of doctoral candidates in the considered field (life sciences/social sciences/engineering respectively) of country i from the region m in the NetReAct (for the life sciences) and Rescar (for engineering and the social sciences) surveys and the number of doctoral candidates in the corresponding field estimated with Eurostat data in country i. The extrapolation is performed using an inflation factor which is the ratio of the number of doctoral candidates in each field in the 9 countries to the total number of doctoral candidates in the corresponding field in the 27 countries, estimated with Eurostat data.

Formally, if $\alpha_{im}$ is the percentage of doctoral candidates in the life sciences (the social sciences and engineering respectively) of country i from the region m in the NetReAct/Rescar survey, we estimate the number of doctoral candidates in the country i from region m $D_{im}$ as follows:
\[ \hat{D}_{im} = \hat{\alpha}_{im} N^C_i \]

Where \( N^C_i \) is the number of doctoral candidates in the corresponding field estimated with Eurostat data in the country \( i \).

The total number of doctoral candidates in the life sciences (the social sciences and engineering respectively) in the EU-27 from the region \( m \) is extrapolated with an inflation factor \( f \) from the total for the 9 countries as:

\[ \hat{D}_{EU27,m} = \frac{\sum_{i\in D} \hat{D}_{im}}{f} \]

with \( D = (CZ, DE, ES, FR, HU, IT, PT, SE, UK) \).

The inflation factor corresponding to each discipline is the ratio of the number of doctoral candidates in the social sciences/engineering in the 9 countries to the total number of doctoral candidates in the corresponding field in the 27 countries, estimated with Eurostat data:

\[ f = \frac{\sum_{i\in D} N^C_i}{\sum_{i=1}^{27} N^C_i} \]

with \( D = (CZ, DE, ES, FR, HU, IT, PT, SE, UK) \).

The same methodology as above is applied for postdoctoral researchers. See also section 3.2 for more details on the surveys and on the calculation methods.

### 4.1.3 Researchers by citizenship

#### 4.1.3.1 Eurostat aggregated data

Little information is available in Eurostat data. Only seven countries have some information on the citizenship of researchers. With this limited information it is impossible to perform any EU extrapolation as these 7 countries represent only 7% of the total number of researchers in the EU-27.
Table 14. Researchers (HC) by citizenship in government and HE sector (2004 and 2005)

<table>
<thead>
<tr>
<th>Citizenship of Europe countries not in EU</th>
<th>Africa</th>
<th>North America</th>
<th>Central and South America</th>
<th>Asia</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</tr>
<tr>
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<td></td>
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</tr>
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</table>

Source: Eurostat. 2005 data for the Czech Republic, 2004 for the other countries. For Slovakia, the sum does not correspond exactly to the total given. Data extracted on 21 November 2007.

Methodology of section 4.1.3.1: Eurostat aggregated data

Data are from Eurostat (based on R&D statistics) and were extracted on 21 November 2007. For more details see section 2.1.

4.1.3.2 Results from national LFS in six countries

This section presents an analysis of the origin (citizenship) of researchers, here called ‘Science, Engineering and Technology (SET) professionals’ in six European countries – France, Germany, the Netherlands, Poland, the UK and Norway – based on data from national Labour Force Surveys (LFS). The term ‘SET professionals’ is used since the concept of researcher is made operational by using a combination of educational level and occupational codes.

‘SET professionals’ are defined as people who fulfil both of the following criteria:

- possession of tertiary education at or above ISCED97 level 5 and;

---

an occupation that is (or could be) applied to SET professionals by ISCO classification.

This population is larger than the population of researchers following the Frascati Manual definition. It constitutes between 3.2% and 4.5% of the labour force in all the countries, except in the UK where it is only 1.5% (Table 15).

The proportion of non-nationals ‘SET professionals’ is 4.5% in the Netherlands, 4.8% in France, 6.2% in Germany, 7% in Norway and 10.2% in the UK. It is very low (0.1%) in Poland.

The proportion of non-nationals ‘SET professionals’ with EU-25 citizenships ranges from 0.1% in Poland to 4.6% in Norway. The share of non-nationals with EU-25 citizenships (in the non-nationals) is 26% in the Netherlands, 36% in the UK, 53% in Germany, 55% in France, 66% in Norway and 100% in Poland.

The proportion of non-nationals SET professionals with citizenships outside EU-25 ranges from 0% in Poland to 6.6% in the UK.

**Table 15. ‘SET professionals’ by citizenship in 6 European countries (circa 2004)**

<table>
<thead>
<tr>
<th></th>
<th>Total ‘SET professionals’</th>
<th>Non-nationals, intra-EU-25 (A)</th>
<th>Non-nationals, extra-EU-25</th>
<th>Non-nationals, Total (B)</th>
<th>Share of intra-EU among non-nationals (A / B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Share in labour force</td>
<td>Number %</td>
<td>Number %</td>
<td>Number %</td>
<td>Number %</td>
</tr>
<tr>
<td>France</td>
<td>865 013</td>
<td>3.21</td>
<td>22 978 2.7</td>
<td>18 747 2.2</td>
<td>41 725 4.8</td>
</tr>
<tr>
<td>Germany</td>
<td>1 670 307</td>
<td>4.21</td>
<td>54 535 3.3</td>
<td>49 714 3.0</td>
<td>103 791 6.2</td>
</tr>
<tr>
<td>Netherlands*</td>
<td>333 450</td>
<td>4.54</td>
<td>3 885 1.2</td>
<td>11 239 3.4</td>
<td>15 124 4.5</td>
</tr>
<tr>
<td>Poland**</td>
<td>671 000</td>
<td>3.94</td>
<td>1 000 0.1</td>
<td>0 0.0</td>
<td>1 000 0.1</td>
</tr>
<tr>
<td>UK</td>
<td>434 893</td>
<td>1.50</td>
<td>15 842 3.6</td>
<td>28 560 6.6</td>
<td>44 402 10.2</td>
</tr>
<tr>
<td>Norway</td>
<td>87 600</td>
<td>4.00</td>
<td>4 050 4.6</td>
<td>2 100 2.4</td>
<td>6 150 7.0</td>
</tr>
</tbody>
</table>


**Methodology of section 4.1.3.2: ‘SET professionals’**


LFS is the main statistical tool available for mapping labour force participation, labour market status and other labour-related issues of populations. It is conducted comparatively in all the countries (following guidelines from the International Labour Organisation - ILO) and contains data on a large number of variables such as education, occupation, industrial affiliation etc.

‘SET professionals’ are defined as people who fulfil both of the following criteria:
- Possessing tertiary education at or above ISCED97 level 5
- Having an occupation defined by the following codes:
  - ISCO 211 Physicists, Chemists and Related Professionals
  - ISCO 212 Mathematicians, Statisticians and Related Professionals
  - ISCO 213 Computing Professionals
  - ISCO 214 Architects, Engineers and Related Professionals
  - ISCO 221 Life Science Professionals
  - ISCO 222 Health Professionals (except nursing)
  - ISCO 231 College, University and Higher Education Teaching-Professionals.

This definition is motivated by the HRST Core concept of the Canberra Manual logic, but it is not equivalent to this. It is not known to what extent the people in these occupations really do R&D in their jobs, but like the Canberra manual it can very likely be used as some sort of a proxy for researchers. Indeed, in a preliminary investigation of the German data, the study found that this ‘researcher’ group was numerically quite close to the group constituted by the question in the German LFS: ‘Do you perform R&D work tasks?’ and took this as an indication that the ‘Researcher’ group for Germany is quite close to the group of people who actually perform R&D work as part of their profession.

The indicator of citizenship is used as a proxy for international mobility but it is far from being perfect. Others may be place of birth, place of study, ethnicity, place of past work or combinations of these. This choice has the foremost pragmatic reason that this variable is available in all countries (except the Netherlands where country of birth is used) and it is expected to be of rather good quality in all the LFS datasets.

The major finding of this work is that LFS cannot be considered a reliable statistical source for studies of ‘internationally mobile SET professionals’. The main reason for this is that ‘internationally mobile SET professionals’ (using citizenship as proxy) constitute a proportion of between 0.1 and 10% of the group of SET professionals, the latter being a very small part of the labour force (varying between 1.5 and 4.5% of the countries in the analysis). These types of mobile SET professionals cannot be studied with a sufficient degree of precision and reliability by a universal sample survey as the LFS which has a sample size of less than 1% of the population in working age. Moreover, when breaking down this marginal group by variables like gender, age intervals, field of research and study, the error margins explode.

In addition to the problem of large error margins (which are calculable), we have serious reservations of LFS as an adequate data source for studies of researcher mobility due to the fact that the classification of occupation (ISCO) turns out to be very weak for classifying this type of labour. There are indications that there are different classification practices and work organisational cultures between countries leading to rather random and differing classifications of special types of workers. As an example of dubious results from LFS is the estimate of the stock of SET professionals – which should be far more reliable than the estimation of flows – it is three times larger in Germany than in the UK.

Reference:

4.1.4 Human Resources for Science and Technology Core by citizenship and country of birth

4.1.4.1 The situation in 2006

In the 14 EU Member States where data are available and reliable on Human Resources in Science and Technology Core (HRSTC)\(^{45}\), on average, in 2006, 4.4% of HRSTC were non-nationals (Table 16): 2.4% were non-nationals having EU-27 citizenship (“intra-EU-27”) and 2% were non-nationals having citizenship outside EU-27 (“extra-EU-27”). The highest share of non-nationals is found in Luxembourg (51.1% and Austria (10.6%). The highest share of non-nationals with EU-27 citizenship is found in Luxembourg (48.9%) and Belgium (4.9%), and the lowest share in Finland (0.5%), Czech Republic and Greece (0.7% both). The highest share of non-nationals with citizenship outside EU-27 is found in UK (4.0%) and Austria (2.9%). The share of non-nationals EU citizens among the total non-nationals, given in the last column of the table, ranges from 37% in the UK to 96% in Luxembourg.

The shares of foreign-born HRSTC are somewhat higher\(^{46}\) (Table 17). On average in the 15 Member States where data are available and reliable\(^{47}\), 9.1% of HRSTC were foreign-born in 2006: 3.2% were born in another EU Member State and 5.9% in a country outside the EU. In 6 countries out of 15 the share of foreign-born HRSTC is higher than 10% (Luxembourg, Austria, Cyprus, UK, Sweden and Portugal); in Luxembourg, more than half of HRSTC were born in another country (and 9 out of 10 of them in another EU Member State) and 16% in Austria (two thirds of them in another EU MS). The share of EU-27 foreign-born ranges from 0.9% in Finland to 46.7% in Luxembourg. The share of HRSTC born in a country outside EU is the highest in the UK (9.2%) and Portugal (7.4%). The share of EU foreign-born among the total foreign-born is the lowest in the UK (26%) and France (29%).

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\(^{45}\) HRSTC in these 14 Member States accounted for 25.8 millions out of the 34.5 millions HRSTC in the EU-27 at a whole (75%). Unfortunately, no data are available for scientists and engineers.

\(^{46}\) Foreign-born immigrants may obtain the citizenship of their country of residence (more or less rapidly according to the country), but their country of birth will never change.

\(^{47}\) The list of countries is slightly different from the one by country of citizenship.
Table 16. Number (in thousands) and share (in %) of non-nationals Human Resources in Science and Technology Core (HRSTC) having EU-27 citizenship and citizenship outside EU-27, 14 Member States (2006)

<table>
<thead>
<tr>
<th>Country</th>
<th>Total HRSTC</th>
<th>Non-nationals intra-EU-27</th>
<th>Non-nationals extra-EU-27</th>
<th>Non-nationals, total</th>
<th>Share of intra-EU-27 non-nationals among total non-nationals (A / B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Belgium</td>
<td>919</td>
<td>45</td>
<td>4.9</td>
<td>8</td>
<td>0.9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>537</td>
<td>4</td>
<td>0.7</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>676</td>
<td>13</td>
<td>1.9</td>
<td>11</td>
<td>1.6</td>
</tr>
<tr>
<td>Germany</td>
<td>6,416</td>
<td>162</td>
<td>2.5</td>
<td>104</td>
<td>1.6</td>
</tr>
<tr>
<td>Greece</td>
<td>754</td>
<td>5</td>
<td>0.7</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>Spain</td>
<td>3,519</td>
<td>94</td>
<td>2.7</td>
<td>75</td>
<td>2.1</td>
</tr>
<tr>
<td>France</td>
<td>4,567</td>
<td>63</td>
<td>1.4</td>
<td>69</td>
<td>1.5</td>
</tr>
<tr>
<td>Cyprus</td>
<td>65</td>
<td>3</td>
<td>4.6</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>45</td>
<td>22</td>
<td>48.9</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,640</td>
<td>33</td>
<td>2.0</td>
<td>12</td>
<td>0.7</td>
</tr>
<tr>
<td>Austria</td>
<td>443</td>
<td>34</td>
<td>7.7</td>
<td>13</td>
<td>2.9</td>
</tr>
<tr>
<td>Finland</td>
<td>550</td>
<td>3</td>
<td>0.5</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>1,005</td>
<td>30</td>
<td>3.0</td>
<td>15</td>
<td>1.5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>4,704</td>
<td>110</td>
<td>2.3</td>
<td>188</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Total 14 MS</strong></td>
<td><strong>25,840</strong></td>
<td><strong>621</strong></td>
<td><strong>2.4</strong></td>
<td><strong>508</strong></td>
<td><strong>2.0</strong></td>
</tr>
<tr>
<td>Norway</td>
<td>565</td>
<td>16</td>
<td>2.8</td>
<td>6</td>
<td>1.1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>763</td>
<td>115</td>
<td>15.1</td>
<td>34</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS based on Eurostat data.
### Table 17. Number (in thousands) and share (in %) of foreign-born Human Resources in Science and Technology Core (HRSTC), EU-27 foreign-born and non-EU-27 foreign-born, 15 Member States (2006)

<table>
<thead>
<tr>
<th></th>
<th>Total HRSTC</th>
<th>Foreign-born, EU-27 (A)</th>
<th>Foreign-born, non-EU-27 (B)</th>
<th>Foreign-born, Total (C)</th>
<th>Share of EU-27 foreign-born among total foreign-born (A / B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>919</td>
<td>47</td>
<td>5.1</td>
<td>43</td>
<td>4.7</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>536</td>
<td>8</td>
<td>1.5</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Denmark</td>
<td>674</td>
<td>17</td>
<td>2.5</td>
<td>24</td>
<td>3.6</td>
</tr>
<tr>
<td>Greece</td>
<td>754</td>
<td>9</td>
<td>1.2</td>
<td>9</td>
<td>1.2</td>
</tr>
<tr>
<td>Spain</td>
<td>3 519</td>
<td>104</td>
<td>3.0</td>
<td>161</td>
<td>4.6</td>
</tr>
<tr>
<td>France</td>
<td>4 526</td>
<td>123</td>
<td>2.7</td>
<td>303</td>
<td>6.7</td>
</tr>
<tr>
<td>Cyprus</td>
<td>65</td>
<td>5</td>
<td>7.7</td>
<td>4</td>
<td>6.2</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>45</td>
<td>21</td>
<td>46.7</td>
<td>2</td>
<td>4.4</td>
</tr>
<tr>
<td>Hungary</td>
<td>569</td>
<td>12</td>
<td>2.1</td>
<td>5</td>
<td>0.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1 639</td>
<td>45</td>
<td>2.7</td>
<td>95</td>
<td>5.8</td>
</tr>
<tr>
<td>Austria</td>
<td>444</td>
<td>47</td>
<td>10.6</td>
<td>24</td>
<td>5.4</td>
</tr>
<tr>
<td>Portugal</td>
<td>525</td>
<td>18</td>
<td>3.4</td>
<td>39</td>
<td>7.4</td>
</tr>
<tr>
<td>Finland</td>
<td>550</td>
<td>5</td>
<td>0.9</td>
<td>6</td>
<td>1.1</td>
</tr>
<tr>
<td>Sweden</td>
<td>1 004</td>
<td>52</td>
<td>5.2</td>
<td>59</td>
<td>5.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>4 704</td>
<td>149</td>
<td>3.2</td>
<td>433</td>
<td>9.2</td>
</tr>
<tr>
<td><strong>Total 15 MS</strong></td>
<td><strong>20 473</strong></td>
<td><strong>662</strong></td>
<td><strong>3.2</strong></td>
<td><strong>1 211</strong></td>
<td><strong>5.9</strong></td>
</tr>
<tr>
<td>Norway</td>
<td>564</td>
<td>23</td>
<td>4.1</td>
<td>19</td>
<td>3.4</td>
</tr>
<tr>
<td>Switzerland</td>
<td>762</td>
<td>131</td>
<td>17.2</td>
<td>63</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS based on Eurostat data.

### 4.1.4.2 Evolution over 2000-06

Data are available and reliable over the period 2000-06 for 9 EU Member States by nationality (Table 18) and 10 EU Member States by country of birth (Table 19).

Non nationals HRSTC having EU-27 citizenship increased from 229,000 in 2000 to 376,000 in 2006 in these 9 countries, i.e. +8.6% p.a. (Table 18 and Figure 49). Their share in the HRTC total increased from 2.2% in 2000 to 2.9% in 2006. In Spain and the UK, we observe respectively an increase from 26 000 to 94 000 and from 80 000 to 110 000. Non-nationals having citizenship outside EU-27 increased slightly more from 167 000 in 2000 to 318 000 in 2006 in the 9 Member States under consideration (+11.3% p.a.). Their share in the HRSTC total increased from 1.6% to 2.4%. Spain and the UK observed strong increases, from 16 000 to 75 000 and from 105 000 to 188 000 respectively.

EU-27 foreign-born HRSTC increased from 345 000 in 2000 to 496 000 in 2006 (+6.2% p.a.) in the 10 EU Member States under consideration (Table 19 and Figure 50). Their share in the total increased from 3.2% to 3.6% on the same period. The increase was particularly strong in Spain (from 42 000 to 104 000). HRSTC born in a country outside EU-27 increased more, from 524 000 to 854 000 in the 10 Member States (+8.5% p.a.). The share in the HRSTC total increased from 4.9% to 6.2%. The increase was strong in Spain (from 51 000 to 161 000) and the UK (from 291 000 to 433,000).
Table 18. Non-nationals Human Resources in Science and Technology Core (HRSTC): numbers (in thousands) and shares (in %) in 2000 and 2006, annual growth rates (in %) and evolution of the shares (in percentage points) over 2000-06

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2006</th>
<th>2000-06, average annual growth rates in % and evolution of the share in percentage points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>36</td>
<td>4.5</td>
<td>7</td>
</tr>
<tr>
<td>Greece</td>
<td>4</td>
<td>0.7</td>
<td>3</td>
</tr>
<tr>
<td>Spain</td>
<td>26</td>
<td>1.1</td>
<td>16</td>
</tr>
<tr>
<td>Cyprus</td>
<td>3</td>
<td>6.4</td>
<td>1</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>12</td>
<td>38.7</td>
<td>1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>27</td>
<td>2.1</td>
<td>10</td>
</tr>
<tr>
<td>Austria</td>
<td>17</td>
<td>5.2</td>
<td>11</td>
</tr>
<tr>
<td>Sweden</td>
<td>24</td>
<td>2.6</td>
<td>13</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>80</td>
<td>2.0</td>
<td>105</td>
</tr>
<tr>
<td><strong>Total 9 MS</strong></td>
<td>229</td>
<td>2.2</td>
<td>167</td>
</tr>
</tbody>
</table>

Source: JRC-IPTS based on Eurostat data.

Figure 49. Non-nationals Human Resources in Science and Technology Core (HRSTC) in 9 EU Member States: numbers (in thousands) and shares (in %) from 2000 to 2006

Source: Eurostat.
Table 19. Foreign-born Human Resources in Science and Technology Core (HRSTC): numbers (in thousands) and shares (in %) in 2000 and 2006, annual growth rates (in %) and evolution of the shares (in percentage points) over 2000-06

<table>
<thead>
<tr>
<th>Country</th>
<th>Foreign born EU-27</th>
<th>%</th>
<th>Foreign born non-EU-27</th>
<th>%</th>
<th>Foreign born EU-27</th>
<th>%</th>
<th>Foreign born non-EU-27</th>
<th>%</th>
<th>2000-06, average annual growth rates in % and evolution of the share in percentage points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>38</td>
<td>4.8</td>
<td>30</td>
<td>3.8</td>
<td>47</td>
<td>5.1</td>
<td>43</td>
<td>4.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>9</td>
<td>1.8</td>
<td>11</td>
<td>2.2</td>
<td>17</td>
<td>2.5</td>
<td>24</td>
<td>3.6</td>
<td>11.2</td>
</tr>
<tr>
<td>Greece</td>
<td>9</td>
<td>1.6</td>
<td>10</td>
<td>1.8</td>
<td>9</td>
<td>1.2</td>
<td>9</td>
<td>1.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Spain</td>
<td>42</td>
<td>1.8</td>
<td>51</td>
<td>2.2</td>
<td>104</td>
<td>3.0</td>
<td>161</td>
<td>4.6</td>
<td>16.3</td>
</tr>
<tr>
<td>Cyprus</td>
<td>3</td>
<td>6.4</td>
<td>2</td>
<td>4.3</td>
<td>5</td>
<td>7.7</td>
<td>4</td>
<td>6.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>12</td>
<td>38.7</td>
<td>2</td>
<td>6.5</td>
<td>21</td>
<td>46.7</td>
<td>2</td>
<td>4.4</td>
<td>9.8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>41</td>
<td>3.2</td>
<td>80</td>
<td>6.3</td>
<td>45</td>
<td>2.7</td>
<td>95</td>
<td>5.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Austria</td>
<td>26</td>
<td>8.0</td>
<td>16</td>
<td>4.9</td>
<td>47</td>
<td>10.6</td>
<td>24</td>
<td>5.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>44</td>
<td>4.8</td>
<td>31</td>
<td>3.4</td>
<td>52</td>
<td>5.2</td>
<td>59</td>
<td>5.9</td>
<td>2.8</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>121</td>
<td>3.0</td>
<td>291</td>
<td>7.2</td>
<td>149</td>
<td>3.2</td>
<td>433</td>
<td>9.2</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Total 10 MS</strong></td>
<td><strong>345</strong></td>
<td><strong>3.2</strong></td>
<td><strong>524</strong></td>
<td><strong>4.9</strong></td>
<td><strong>496</strong></td>
<td><strong>3.6</strong></td>
<td><strong>854</strong></td>
<td><strong>6.2</strong></td>
<td><strong>6.2</strong></td>
</tr>
</tbody>
</table>

Source: JRC-IPTS based on Eurostat data.

Figure 50. Foreign-born Human Resources in Science and Technology Core (HRSTC) in 10 EU Member States: numbers (in thousands) and shares (in %) from 2000 to 2006

Source: Eurostat.
Methodology of section 4.1.4: HRSTC

Data are from Eurostat. Human Resources for Science and Technology Core (HRSTC) are people who fulfil both of the following conditions:

a) successfully completed third-level education in an S&T field of study;

b) not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required.

For more precisions on definitions, sources and general statistical results, please see section 2.1 above.

4.2 International mobility out of the EU

Section 5.2.1 will analyse the presence of European doctoral graduates in the US. Section 5.2.2 will provide results on the scholars of EU origin in the US.

4.2.1 European doctoral graduates in the US

4.2.1.1 Origin of doctoral recipients in the US: all disciplines

In 2005, 43 300 doctorates were granted by US universities\(^\text{48}\). Of the 2005 doctorate recipients with known citizenships\(^\text{49}\), about 35% were non-US citizens (4% non-US citizens with permanent resident visas and 31% non-US citizens with temporary visas).

Top countries of origin

In the US, the top country in terms of the number of doctorates conferred to its citizens is China, which accounts for 9.4% of all doctorates conferred by US universities with known citizenships (or 27% of the number of doctoral recipients non-US citizens) (see Figure 51). The top following countries are as follows: South Korea (3.8% of all doctorates with known citizenships), India (3.1%), Taiwan (1.8%) and Canada (1.4%).

Among the top 30 countries\(^\text{50}\), there are 8 EU countries that rank as follows: Germany (11\(^{th}\), 0.61%), Romania (12\(^{th}\), 0.52%), Italy (14\(^{th}\), 0.45%), the UK (15\(^{th}\), 0.41%), France (17\(^{th}\), 0.37%), Spain (20\(^{th}\), 0.30%), Greece (23\(^{rd}\), 0.26%) and Bulgaria (26\(^{th}\), 0.23%). There were nearly 1 300 doctoral recipients from these 8 EU countries in the US in 2005. That accounts

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\(^{49}\) About 40 700 with known citizenships and 2 600 with unknown citizenships.

\(^{50}\) Unfortunately, we it is not possible to obtain the full list of countries with the data publicly available.
for 3.1% of the total number of doctorates with known citizenships conferred by US institutions (or 9% of the number of non-US citizens earning doctorates). Data for the other countries are not publicly available.

**Figure 51. Top 30 countries of origin of non-US citizens conferred doctorates in the US (2005)**


**Out migration of doctoral recipients of EU origin: a relative measure**

For these eight EU countries, we calculated the ratio of the number of doctorates earned in the US to the number of doctorates conferred at home. On average, it is 1.8%, i.e. US universities conferred about 1.8 doctorate to citizens of these 8 countries for every 100 granted at home. This ratio ranges from 17.4% for Bulgaria to 1% for Germany (Figure 52).
Figure 52. Ratio of doctorates conferred in the US to doctorates conferred at home (%)


4.2.1.2 Origin of doctoral recipients in the US: S&E disciplines

Main regions of origin: recent evolution

In 2004, 26 275 doctorates were conferred in S&E fields by US universities. Of these, 10 040 were conferred to non-US citizens, i.e. 40% among those with known citizenships.

The evolution of the number of foreign doctoral graduates by main regions of origin over the period 1995 to 2004 is provided in Figure 53. The number of doctoral candidates with European citizenship has evolved — around 1 500 — from 1998 to 2004. The number of doctoral candidates from Asia (east and west Asia grouped together) is clearly higher (7 800 in 1995 and 6 700 in 2004). Therefore, Europeans and Asians account for about 6.6% and 26.9% respectively of S&E doctoral graduates with known citizenships conferred in the US.

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52 In the S&E fields, 1 432 are of unknown nationalities in 2005.

53 All Europe, including east European countries.

Source: JRC-IPTS with National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates.

Doctoral recipients of EU origin

Data are publicly available for four European citizenships: Germany, UK, France and Belgium. A total of 184, 110 and 91 S&E doctoral graduates respectively were conferred to citizens from Germany, the UK and France, in the US in 2004. These three citizenships together account for 1.5% of the total number of S&E doctoral graduates (with known nationalities) conferred by US universities that year. All the other European countries (including east European countries) accounted for 5.1%.

The evolution of the number and percentage of S&E doctorates conferred to Europeans (separating the 'three big' countries from all the other European countries) over the period 1995 to 2004 is provided in Figure 54. The number (and percentage) of S&E doctorates conferred to citizens from the 'three big' countries has tended to stay relatively stable over time, whereas the number (and percentage) of S&E doctoral conferred to citizens from all the rest of Europe has tended to increase. However, this increase may be attributed to east European countries rather than to EU countries \(^{54}\).

\(^{54}\) This is the limit of this analysis with the data publicly available.
Figure 54. Number and percentage of US S&E doctorates conferred to European citizens (1995-2004)

Source: JRC-IPTS with National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates. Number of doctorates conferred to citizens from Germany, France and the UK, and to other European countries (right axis). Percentage: among the total number of S&E doctorates with known citizenships (left axis).

Methodology of section 4.2.1: European doctorates in the US

These calculations are based on data from the US NSF/NIH/USED/NEH/USDA/NASA Survey of Earned Doctorates (SED)55. The SED is a federal agency survey sponsored by the National Science Foundation and five other federal agencies (National Institutes of Health, US Department of Education, National Endowment for the Humanities, US Department of Agriculture, and National Aeronautics and Space Administration). NORC at the University of Chicago is the current contractor selected by the National Science Foundation to conduct the SED.

In 1957 and 1958, the SED began to continuously collect data on the number and characteristics of individuals receiving research doctoral degrees from all accredited US institutions. The results of this annual survey are used to assess characteristics and trends in doctorate education and degrees. Today, the SED gathers information annually from about 45 000 new US research doctorate graduates about their educational histories, funding sources, and postdoctoral plans.

4.2.2 Scholars of EU origin in the US

4.2.2.1 Foreign scholars in the US

Recent evolution by broad regions of origin

In 2005 and 2006, nearly 97 000 foreign scholars were working in the US (Figure 55). The population of foreign scholars in the US increased from 80 000 in 2000/01 to 86 000 in

2001/02, slightly decreased in 2002/03 and 2003/04, and then increased in 2004/05 (90 000) and 2005/06 (97 000).

Asia is the leading place of origin for foreign scholars in the US, with some 48 000 individuals in 2005/06 (55.6% of the total number of foreign scholars hosted in the US). The number of Asians was 36 000 in 2000/01. It remained relatively stable from 2001/02 to 2003/04 at a level of about 39 000, and then increased. The share of Asians (among the total number of foreign scholars in the US) increased as well, from about 45% from 2000/01 to 2002/03, to 50.8% in 2004/05 and 55.6% in 2005/06.

In 2005 and 2006, nearly 25 000 scholars hosted in the US came from the EU-27. They accounted for about 29% of the total number of foreign scholars in the US. The number of scholars of EU origin was relatively stable at about 23 000 in 2000/01 and 2001/02. It decreased in 2002/03 to 21 700, and then increased slightly over the rest of the period to reach 24 900 in 2005/06. The share of scholars of EU origin decreased from 28.8% in 2000/01 to 25.2% in 2002/03 and then increased to reach 29% in 2005/06.

**Figure 55. Number of international scholars in the US by broad regions of origin (2001-2006)**

Source: JRC-IPTS with Open Doors data.

**Top 50 countries of origin**

The top country of origin of foreign scholars in the US is China, with some 19 000 individuals (Figure 56), which accounts for about one fifth of the total number of foreign scholars in the US. It is followed by Korea (8 900), India (8 800) and Japan (5 600). The first EU country, Germany, ranks fifth with 5 100 individuals. These top five countries account for nearly half of the total number of foreign scholars hosted in the US.
Among the top 10 countries of origin of foreign scholars in the US in 2005 and 2006, there are four EU countries (Germany in fifth place, France in seventh, the UK in eighth and Italy in ninth place).

Figure 56. Top 50 countries of origin of foreign scholars in the US (2005-06)

Source: JRC-IPTS with Open Doors data.

Main functions and main fields

In 2005/06, three quarters of foreign scholars in the US had research as a primary function, 12% teaching, 7% both research and teaching and 5% other functions (Figure 57). Over the last few years, these shares have remained relatively stable.

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56 These 10 countries account for two thirds of the total number of foreign scholars.
In 2005/06, 43% of foreign scholars hosted in the US were in life and health sciences (23% in life and biological sciences and 20% in health), 12% in physical sciences and 11% in engineering (Figure 58). The other disciplines represent each less than 5%. Over the last few years, these proportions have been relatively stable.

**Figure 57. Primary function of foreign scholars in the US (2005/06)**

![Pie chart showing the primary function of foreign scholars in the US (2005/06).](chart1)

Source: JRC-IPTS with Open Doors data.

**Figure 58. Fields of specialisation of foreign scholars in the US (2005/06)**

![Pie chart showing the fields of specialisation of foreign scholars in the US (2005/06).](chart2)

Source: JRC-IPTS with Open Doors data.
4.2.2.2 Scholars of EU origin in the US

Leading countries of origin

In 2005 and 2006, there were some 25 000 scholars of EU origin in the US. Germany ranked first with 5 100 scholars, France second with 3 400 scholars, the UK third with 3 300 scholars and Italy fourth with 3 000 scholars. The first 10 EU countries account for 84% of the total number of scholars of EU origin in the US (Figure 59).

Figure 59. Scholars of EU origin in the US, by country of origin (2005-06)

Source: JRC-IPTS with Open Doors.

A measure of the relative out mobility per country

Compared to the size of the local academic workforce — measured as the total number of researchers (HC) in the higher education and government sectors 57 — 2.3 scholars hold positions in the US per 100 working at home on average in the EU 58. This ratio (Figure 60) is the highest for Cyprus (7.4), Ireland (4.7), the Netherlands (4.7), Romania (4.6) and Italy (4.0).

57 Unfortunately, a more appropriate indicator does not exist.

58 Where data are available, i.e. for 24 EU countries. According to our calculations with Eurostat data, 901 000 researchers (HC) were working in the 24 EU countries in 2003 (data are not available for the UK, Austria and Finland), whereas there were some 21 000 scholars from these 24 EU countries in the US in 2005 and 2006.
Figure 60. Ratio of the number of scholars in the US to the number of researchers in the HE and government sectors at home, per country (%)

Source: JRC-IPTS. The number of scholars, year 2005/06, is from Open Doors. The number of researchers comes from Eurostat (2003, the last most complete year).

Methodology of section 4.2.2: European scholars in the US

Data

OpenDoors presents comprehensive information on international students and scholars in the US and on US students who sojourn abroad as part of their academic experience. More precisely, OpenDoors is a source for basic trends in:

- international students coming to study in US,
- international scholars for a short- or long-term visit to the US,
- US students studying abroad.

The Institute of International Education Research department sends surveys to accredited institutions of higher education in the United States each year. The institutions report on foreign students who are enrolled at their colleges and universities. The data presented are obtained each year, through a survey conducted the prior fall and spring semesters by campus officials at 2 700 accredited US institutions, with a response rate of approximately 90%. Separate surveys were conducted for foreign scholars and US students studying abroad.

OpenDoors uses the 2000 Carnegie classification (see [www.carnegiefoundation.org/classification](http://www.carnegiefoundation.org/classification)).

The classifications are organised around three key questions: What is taught? To whom? In what setting? It focuses on the instructional programme (on the undergraduate programme, and one on the graduate programme) and the profile of enrolled students (the undergraduate and graduate/professional students).

Definitions
An international student is defined as an individual who is enrolled for courses at a higher education institution in the US on a temporary visa, and who is not an immigrant, a refugee or an illegal alien.

Foreign scholars are defined as non-immigrants, non-student academics (teachers and/or researchers, administrators) in the US. The survey was limited to doctoral degree-granting institutions where most J visa scholars were based. Institutions were asked about the primary function of the scholars (research, teaching, both, or other), geographic origin, field of specialisation, sex and visa status.

'Study abroad students' are narrowly defined only as those students who received academic credit from a US accredited institution of higher education after they returned from their study abroad experience.

**Estimates**

Total international student enrolments, US study abroad totals, international scholar totals and the various percentages are calculated directly from campus-based survey responses.

Other student counts are determined by imputation, since not all campuses are able to provide detailed breakdowns by the various categories, such as place of origin, field of study, etc. Estimates of the number of students for each of the variables collected by the various surveys are imputed from the total number of students reported. For each imputation, base or raw counts are multiplied by a correction factor that reflects the ratio of difference between the sum of categories being imputed and the total number of students reported by institutions. For this reason, student totals may vary slightly within different tables. In addition, due to rounding, percentages do not always add up to 100%.

Estimates to account for non-reporting universities for international students and 'study abroad' are based upon the prior year's number adjusted by the average percent change among institutions that reported in the prior and current academic years. For international scholars, estimates were based on numbers reported in the previous year with no additional adjustment.
Abstract

This report discusses the evolution of the stock of researchers in the EU, the supply of higher education graduates and postdoctorates in the EU, and the international mobility of researchers within, into and out of the EU.
The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.