The dynamics of doctoral candidates and post-doctorates in life sciences in Europe and the United States

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Abstract

This paper studies the origin and destination of doctoral candidates and post-doctorates in life sciences in Europe, and gives some elements of comparison for the United States, with a combination of three data sources (Eurostat and NetReAct data for Europe, NSF data for the U.S.). We find that the number of doctoral graduates in life sciences in the EU is higher than in the U.S. (9,000 against 6,000) but the proportion of foreigners is lower in the EU (17% against 29%). The number of postdoctorates in life sciences is more or less the same in the EU and the U.S. (19,000 against 18,000) but the EU attracts less foreign postdoctorates than the U.S. (25% against 57%). 76% of doctoral graduates in life sciences from EU universities continue to work in the EU after graduation whereas 12% go to the U.S. or Canada, and another 12% go to another country. For postdoctorates from EU universities, percentages are more or less the same (76% stay in the EU, 8% go to the U.S. or Canada and 16% to another country).

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1 Introduction

This paper studies the dynamics of doctoral candidates and post-doctorates in life sciences in Europe and gives some elements of comparison for the United States, with a combination of three data sources. Eurostat provides statistics on the number of doctoral graduates in life sciences in Europe. The NetReAct survey provides detailed information on the doctoral candidates and post-doctorates in 10 European countries. NSF data are used to have information on doctoral graduates and postdocs in the U.S.

Section 2 gives some quantitative elements on the number of junior researchers in life sciences in the EU and the U.S.

Section 3 provides details on the data and the methodology used in the paper.

Section 4 presents results on the origin and destination of doctoral graduates and postdoctorates from EU universities, and gives some elements of comparison with the U.S.

Section 5 discusses the results, and notably tries to assess the validity of the results obtained with the NetReAct survey.

Section 6 concludes the paper.

2 Junior researchers in life sciences in the EU and the U.S.

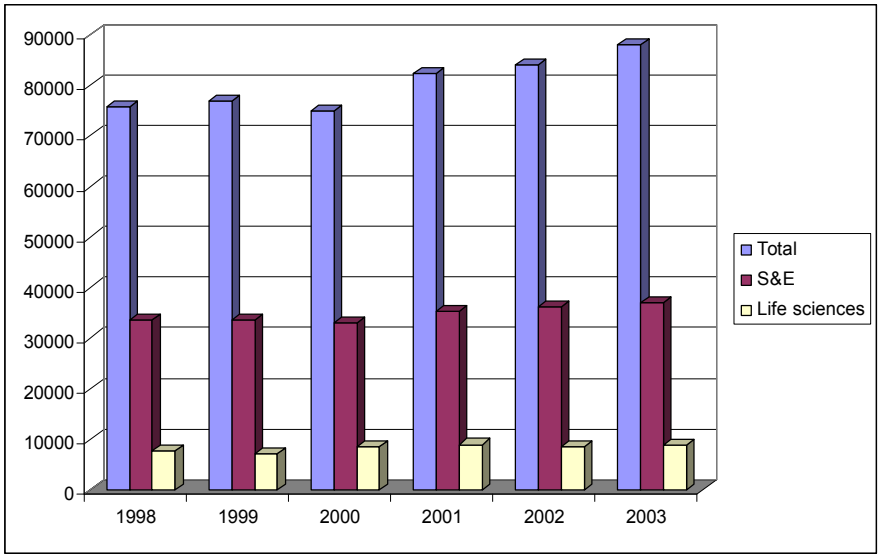
Three main elements make the study of junior scientists in life sciences important and interesting. First, a great proportion of doctoral graduates are in life sciences. Second, the number of postdoctorates in life sciences is higher than in the other fields. Third, the number of foreign postdoctorates is high in life sciences.

2.1 The doctoral graduates in life sciences represent a high share of the total number of doctoral graduates

The total number of ISCED6 graduates in the EU25 is estimated to be about 88,000 in 2003 (Figure 1). By comparison, in the U.S. and Japan, the same year, respectively 46,000 and 14,000 ISCED6 graduates were awarded (Figure 2 and Figure 3). Respectively about 37,000, 16,000 and 5,500 ISCED6 graduates in S&E disciplines (defined according to the "European" definition by the sum of the two main groups "science, mathematics and computing" and "engineering, manufacturing and construction") were granted in the EU25, the U.S. and Japan.

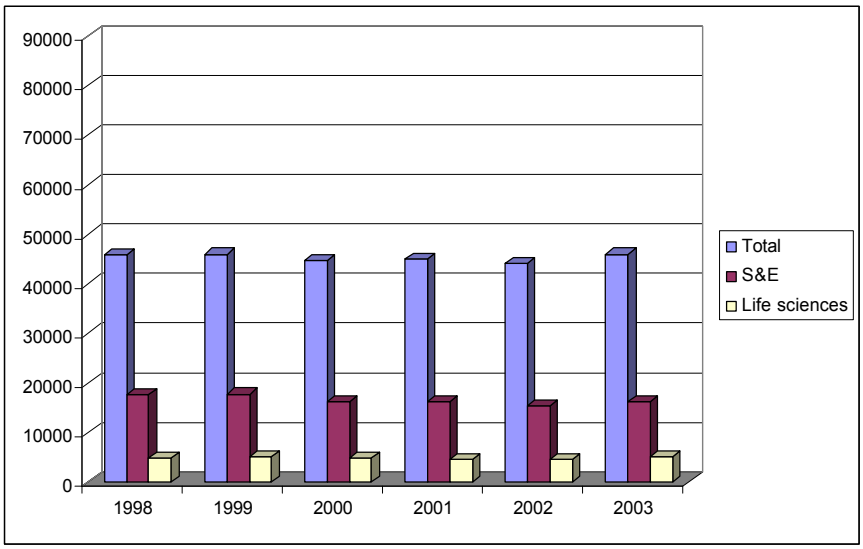
From 1998 to 2003, the number of ISCED6 graduates has been on the increase in the EU25 (+16.3% for all disciplines and +10.1% for S&E disciplines) and has remained more or less stable for all disciplines in the U.S. (whereas it has decreased by 8.0% in S&E disciplines).

Figure 1. Evolution of the number of ISCED6 graduates in the EU25 by main fields (1998-2003)



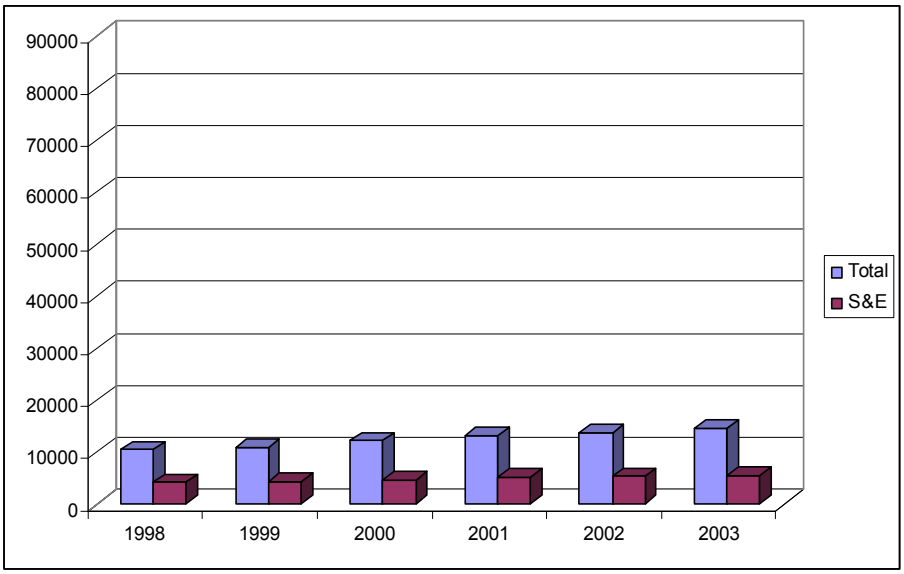
Source: IPTS with Eurostat data. S&E is the sum of the two categories "science, mathematics and computing" and "engineering, manufacturing and construction".

Figure 2. Evolution of the number of ISCED6 graduates in the U.S. by main fields (1998-2003)



Source: IPTS with Eurostat data. S&E is the sum of the two categories "science, mathematics and computing" and "engineering, manufacturing and construction".

Figure 3. Evolution of the number of ISCED6 graduates in Japan by main fields (1998-2003)

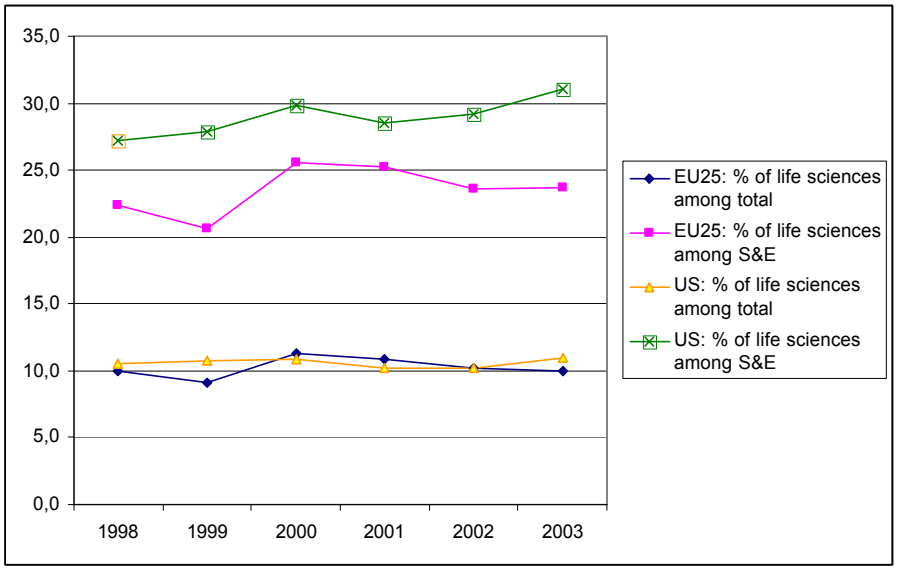


Source: IPTS with Eurostat data. S&E is the sum of the two categories "science, mathematics and computing" and "engineering, manufacturing and construction". No data available for life sciences. 1998: our backward estimations based on a linear trend model estimated on the period 1999-2003.

The number of ISCED6 graduates in life sciences was about 8,800 in the EU25 and 5,000 in the U.S. This number has tended to be relatively stable from 1998 to 2004.

Life sciences accounted for 9.9% of the total number of ISCED6 graduates (23.6% of ISCED6 graduates in S&E) in 2003 in the EU25, and 11.0% (respectively 31.0%) in the U.S. (Figure 4). The percentages among the total have tended to stay relatively the same in the two regions from 1998 to 2004, while the percentages among S&E disciplines has fluctuated around 23% in the EU25 and has tended to slightly increase in the U.S.

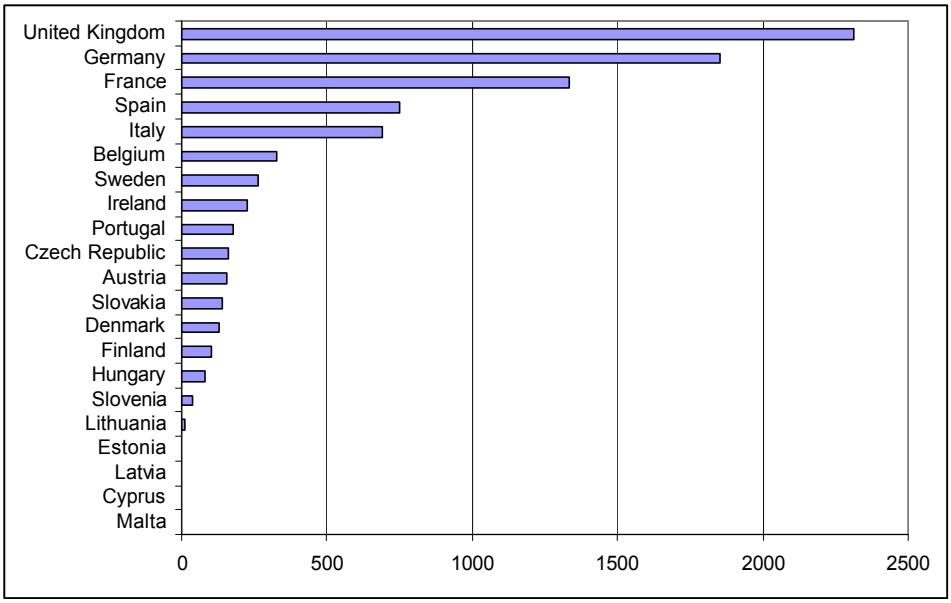
Figure 4. Percentage of ISCED6 graduates in life sciences among the total number of ISCED6 graduates and among ISCED6 graduates in S&E in the EU and U.S. (1998-2003)



Source: IPTS with Eurostat data.

In the EU, the number of ISCED6 graduates in life sciences is the highest in the UK, followed by Germany and France (Figure 5). These three countries accounted for 62.7% of the EU total number of graduates in these disciplines in 2003.

Figure 5. Number of ISCED6 graduates in life sciences in EU countries (2003)



Source: IPTS with Eurostat data.

If we cumulate the number of ISCED6 degrees awarded in life sciences on the period from 1998 to 2003, we see that about 49,000 degrees have been awarded in the EU25 and nearly 29,000 in the U.S. The distribution per country[1] is given in the Figure 6. It is highly concentrated and the ranking of countries is not very different from the ranking of countries based on the number of graduates in 2003.

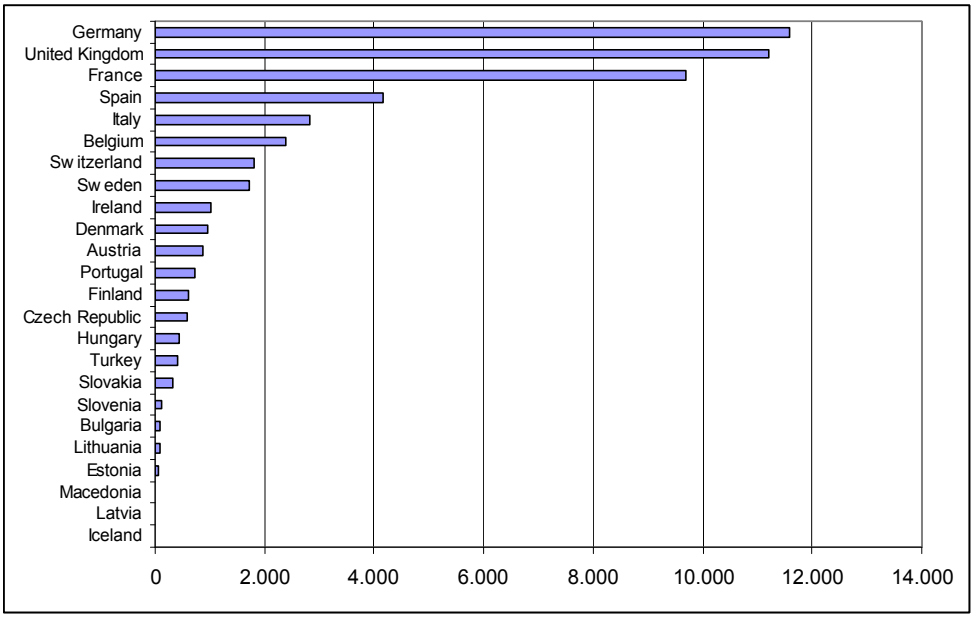
Table 1. Indicators on the evolution of the number of ISCED6 graduates in life sciences in the EU and the U.S.

	Cumulated on the period 1998-03	Variation between 1998 and 2003	Growth rate between 1998 and 2003
European Union (25 countries)	49.145	1.214	16,1
European Union (15 countries)	47.623	899	12,1
New Member States (CZ, EE, CY, LV, LT, HU, MT, PL, SI, SK)	1.522	315	248,0
Euro area (EUR-11 plus GR up to 31.12.2000 / EUR-12 from 1.1.2001)	33.893	179	3,3
United States	28.767	226	4,7

Source: IPTS with Eurostat data.

[1] Missing values have been estimated with basic econometric models.

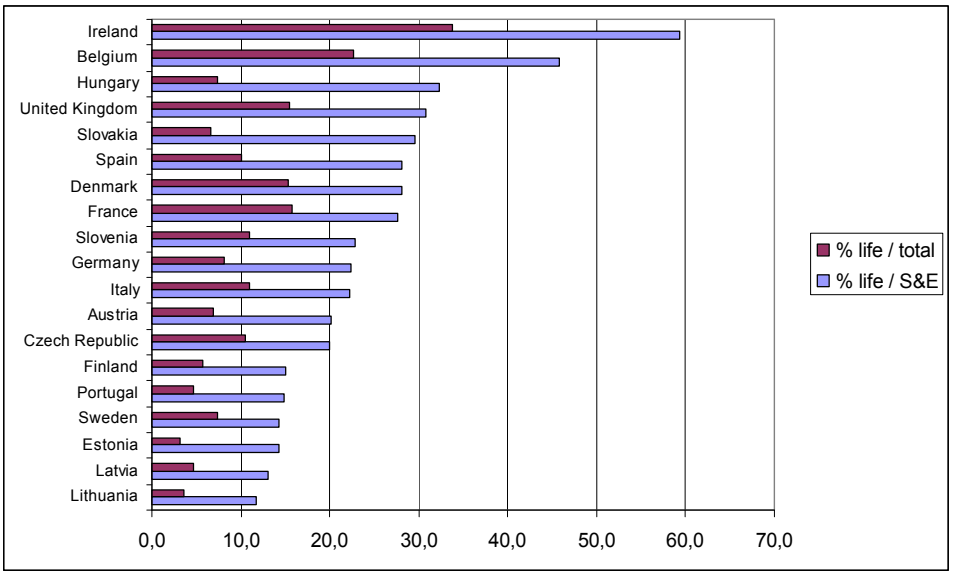
Figure 6. Cumulated number of ISCED6 graduates in life sciences on the period 1998-2003 in European countries



Source: IPTS with Eurostat data. Missing values have been estimated with econometric models.

In the EU, the percentage of ISCED6 graduates among the number of ISCED6 graduates in S&E disciplines (in 2003) ranges from 11.7% in Lithuania to 59.3% in Ireland (Figure 7). The ratios of ISCED6 graduates in life sciences to the total number of ISCED6 graduates ranges from 3.1% in Estonia to 33.8% in Ireland. The rankings of EU countries according to the two ratios are not exactly the same, depending on the relative production of S&E and non-S&E graduates.

Figure 7. Ratio of the number of ISCED6 graduates in life sciences to the total number of ISCED6 graduates and to the number of ISCED6 graduates in S&E disciplines in EU countries (2003)



Source: IPTS with Eurostat data.

2.2 The number of post-doctorates in life sciences is higher than in the other fields

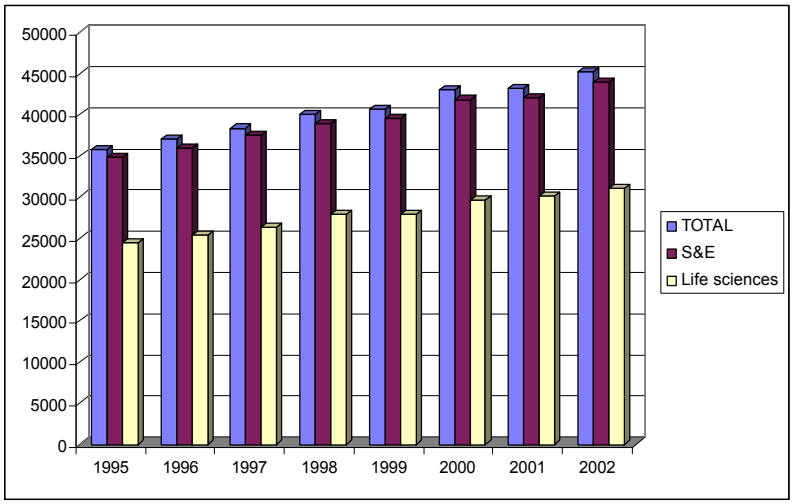
No comprehensive database on postdoctorates is available in Europe. Therefore, we will only rely on U.S. data from NSF in this section.

In the U.S., the data on postdocs come from the NSF Survey of Graduate Students and Postdoctorates in Science and Engineering. The main advantage of this source is that it is NSF's only source of data on foreign-degreed postdocs. The main weaknesses are that it only contains data at the department level (no individual data) and it does not include postdoctorates in non-profit institutions, government agencies, industry or postdocs who are not in formal academic departments.

Some 45,000 postdoctorates in S&E ("U.S." definition: including social sciences[2]) were working in U.S. universities in 2002. It has increased by nearly 10,000 postdocs since 1995 (+26.1%) (Figure 8).

Postdocs in life sciences accounted for 69% of this total in 2002 (40% for biological sciences, i.e. a number of postdocs of nearly 18,000, and 29% for health, i.e. 13,000 postdocs). The other fields accounted for about 13,000, with two main fields concentrated nearly all these postdocs: physical sciences with 6,500 postdocs and engineering with 3,500 (Figure 9).

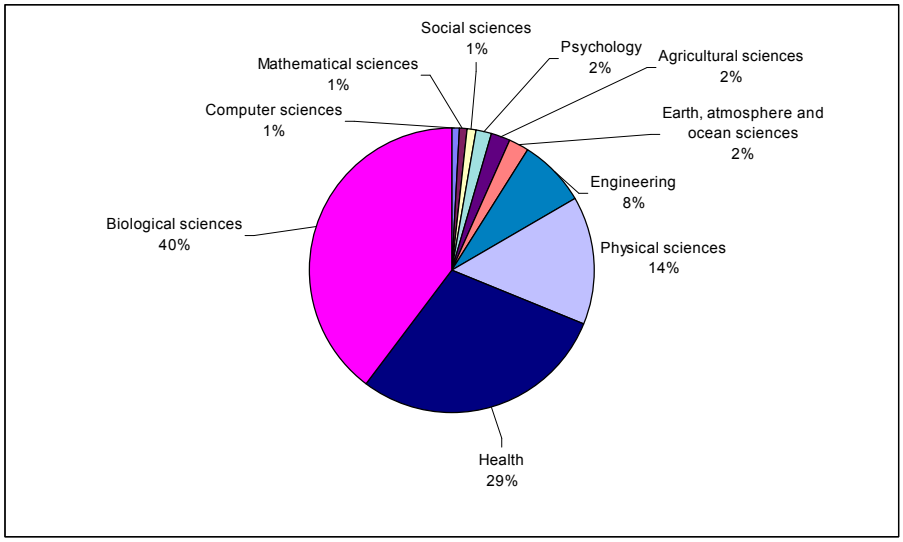
Figure 8. Number of postdoctorates in U.S. universities (1995-2002)



Source: NSF Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS). Total: all disciplines included in the survey ("U.S." definition of S&E: humanities, arts and education are not included, but psychology and social sciences are). S&E ("European" definition): all science and engineering disciplines except psychology and social sciences. Life sciences: biological sciences and health.

[2] However the number of postdocs in social sciences and psychology is rather limited, with respectively 500 and 800 individuals. Therefore, the number of postdocs in S&E ("European" definition, excluding social sciences and psychology) were 44,000 in 2002.

Figure 9. Distribution of postdocs in U.S. universities per disciplines (2002)

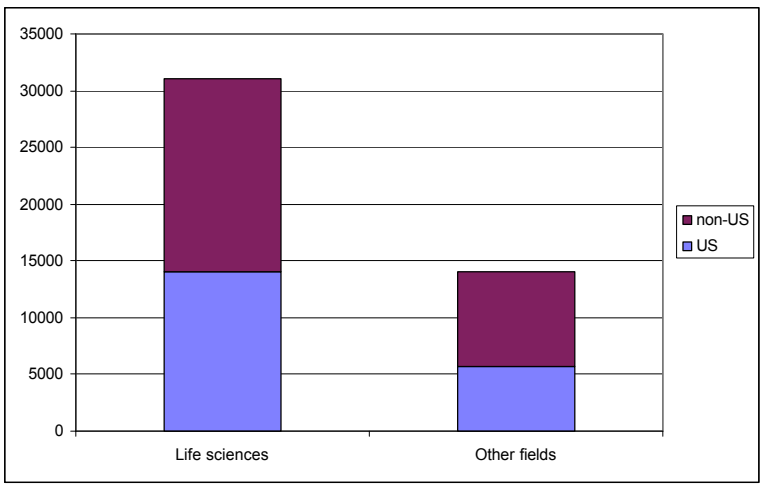


Source: NSF Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS).

2.3 The number of foreign post-doctorates is high in life sciences

Still with NSF data, the number of postdoctorates in U.S. universities non-U.S. citizens temporary visa holders is estimated to be about 25,000 in 2002, which represented 56% of the total number of postdoctorates. In life sciences, 17,000 postdoctorates were non-U.S. citizens temporary visa holders, and wherease the other fields accounted for 8,000 (Figure 10).

Figure 10. Number of post-doctorates in U.S. universities by discipline and citizenship (2002)



Source: NSF. U.S.: U.S. citizens and permanent residents. Non-U.S.: temporary visa holders. Life sciences: biological sciences and health. Other fields: all fields except life sciences.

3 Data and methodology

Three main sources of data have been combined to study the labour market of junior life scientists in Europe: Eurostat, NSF and NetReAct.

3.1 Data

3.1.1 Eurostat data

Eurostat provides statistics on the number of ISCED6 graduates in life sciences (the classification field EF42) in the EU-25 countries. They are harmonized and should be comparable between countries. However, there are some breaks and some inconsistencies in the series that makes it impossible or difficult to identify trends on a long period of time.

3.1.2 The NetReAct survey

The NetReAct survey[3] ("The role of Networking in Research Activities") commissioned by the Institute for Prospective Technological Studies of the European Commission's Joint Research Centre aims at describing and analysing the patterns, dynamics, impacts and strategies of networking in research activities in life sciences. It provides detailed information on the doctoral candidates and post-docs population in 10 European countries (The Czech Republic, France, Germany, Hungary, Italy, Norway, Portugal, Spain, Sweden, and the UK) collected through a questionnaire-based survey addressed to the heads of research teams.

The main unit of analysis in NetReAct is the university-based research team. The International Handbook of Universities was used to identify universities with teams in the life sciences. The field of life sciences has been identified using the K.U. Leuven-IRO Subject Classification, considering five main fields: biology, bio-sciences, bio-medicine, neuro-sciences and other disciplines. From the websites of these universities the names and URLs of the life sciences teams were collected. Further research teams were identified when closely reviewing the web pages of the sample teams.

[3] http://www.netreact-eu.org/

The research population identified by the NetReAct project consists of 7,732 teams working in life sciences, from 359 universities. Strata for sampling were built according to country and a simple importance indicator derived from the webometric analysis. Inlinks were used for the stratification of the population (assumed to be related to the scientific performance of the research teams). Ordering of the teams of each country by inlink class and university was done, i.e. the best performing teams were identified. Drawing probabilities which varied according to the inlink data were calculated so that to introduce some randomness to guarantee that the data is representative at country level. The drawing probabilities were used to draw the sample country-wise from the sorted lists of all research teams obtained. Overall 1,773 teams (23% of the research population) were selected for the sample.

The questionnaire addressed to the heads of these research teams consisted in 31 separate questions mainly on: The research group, research fields, overall personnel numbers; Factors that determine the attractiveness of research teams and PhD students and post-docs in the recruitment process; Characteristics of doctoral students and post-docs; Profiles of the heads of the research teams; Number of collaborating teams and motivations to engage in research collaborations.

After sampling and eliminating the not usable responses, the number of usable questionnaire in the sample was 468 teams, which corresponds to 26% of the respondents included in the sample and 6% of the initial research population.

If these responses are representative of the whole population and if the whole population has been correctly assessed, then, it is possible to estimate the number of doctoral candidates/graduates, the number of postdocs and other staff of the teams, and numerous characteristics of these populations.

3.1.3 U.S. NSF data

The U.S. National Science Foundation provides statistics in the SESTAT system on the number of doctorate graduates and post-doctorates in biological sciences in the U.S.[4] More precisely, data on the number of recent Doctorate graduates come from the Survey of Earned

[4] See for example Stephan and Levin (2001), Ma and Stephan (2004) and NSF (2004, 2005a, 2005b),

Doctorates (SED) whereas the statistics on postdoctorates mainly are from Survey of Graduate Students and Postdoctorates in Science and Engineering (GSS). The field "biological sciences" is taken into account in the remaining of this paper (the field health has not been included as it is too large to be compared with the field life sciences in Eurostat and NetReAct).[5]

3.2 Methodology

Three steps can be distinguished.

- Different characteristics of the doctoral graduates and post-doctorates are extracted from the NetReAct survey (proportion of individuals in different categories) for the 10 countries of the sample;
- These proportions are applied to the number of graduates from Eurostat database to estimate the size of various populations (doctoral graduates, post-doctorates, origin of doctoral graduates and post-doctorates);
- The results are extrapolated at the EU-25 level based on an inflation factor of 0.87 (wihich corresponds to the ratio of the number of doctoral graduates in the sample of 10 countries to the EU25 total given by Eurostat).

4 Results: origin and destination of doctoral graduates and postdoctorates from EU universities

Firsts, the origin of doctoral graduates and postdoctorates from EU universities is studied (and some elements of comparison are given for the U.S.). Second, the destination of doctoral graduates and postdoctorates from EU universities are presented.

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[5] The NSF "biological sciences" field is composed of the following disciplines: Anatomy, Biochemistry, Biology, Biometry/epidemiology, Biophysics, Botany, Cell biology, Ecology, Entomology/parasitology, Genetics, Microbiology, immunology, and virology, Nutrition, Pathology, Pharmacology, Physiology, Zoology, Biosciences, nec.

4.1 Origin of doctoral graduates and postdoctorates from EU universities

4.1.1 Origin of doctoral graduates

8,800 doctorates in life sciences have been granted in EU-25 countries in 2003, according to Eurostat data. By comparison, 5,700 doctorates in biological sciences were granted in the United States in 2003 according to NSF data (65% of the total for EU-25 countries).[6]

In 2003, among the 5,700 doctorate recipients in biological sciences from U.S. universities, 1,700 were not U.S. citizens (29%).[7] The same year, in the EU-25, we estimate[8] that 1,500 doctorates in life sciences (17%) were awarded to non-EU nationals.

Table 2. Doctoral graduates in life sciences in the EU-25 and the U.S., according to nationality (2003)

	EU-25		U.S.	
	Numbers	**%**	**Numbers**	**%**
Nationals	7 277	83.2	4 028	70.7
Non-nationals	1 478	16.8	1 666	29.3
Total	8 755	100	5 694	100

Source: IPTS. Our estimations with data from Eurostat, NSF and the NetReAct survey. U.S.: sum of non U.S. citizens with permanent visas and temporary visas.

We also estimate that 10% of the doctorates granted in life sciences in the EU-25 in 2003 were EU nationals who worked in a Member State of which they did not hold the nationality (intra-EU mobility).

[6] The number of doctorates awarded in the U.S. according to Eurostat data for the field "life sciences" (5,038) slightly differs from the number given by NSF for the field biological sciences (5,694). We work with the NSF numbers so that it can be compared with the number of postdoctorates. Indeed, in the case of postdoctorates, Eurostat does not provide data and we have to work with NSF data.

[7] 265 were non-U.S. citizens with permanent visas and 1,401 were non-U.S. citizens with temporary visas.

[8] In combining NetReAct and Eurostat data.

Table 3. Origin of doctoral graduates in life sciences in EU universities (2003)

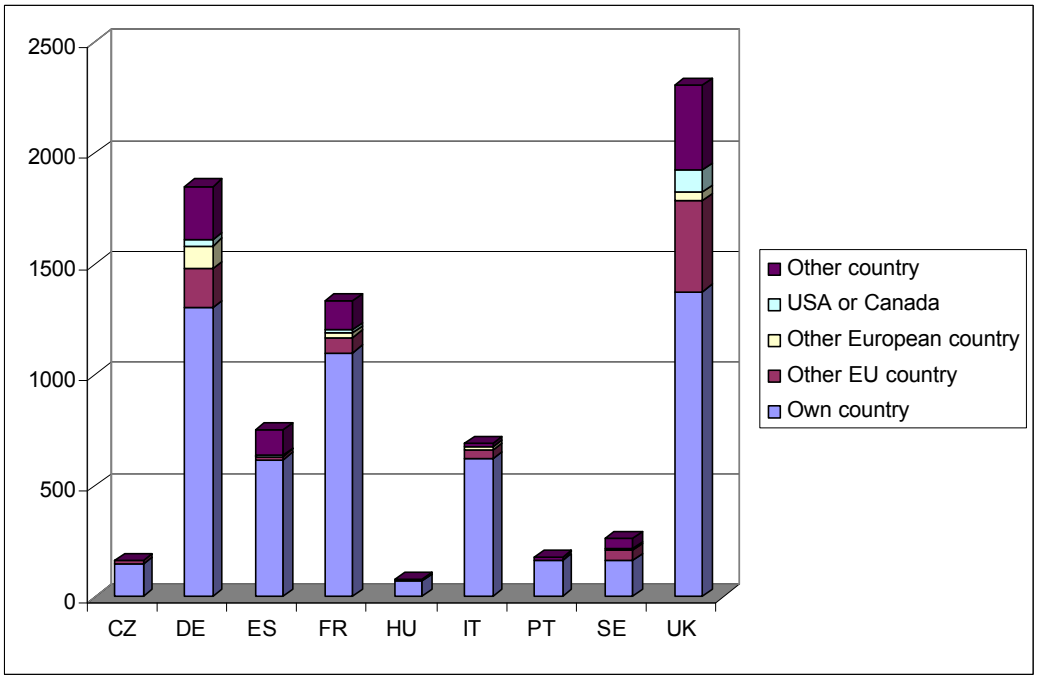
	EU		Non EU			Total
	Own country	Other EU country	Other European country (outside EU)	USA or Canada	Other country	
Numbers	6 400	900	220	170	1 100	8 800
%	73	10	3	2	12	100

Source: IPTS. Our estimations from the NetReAct survey and Eurostat data.

EU-25 attracts few doctoral recipients from Canada and the United States (167 according to our estimations, about 2%) and they are mainly in the United Kingdom (99).

The UK also attracts many EU doctoral candidates. Indeed, we estimate that 409 individuals from EU countries (other than the UK) were granted a Doctorate in life sciences in this country in 2003.

Figure 11. Number of doctoral graduates in life sciences awarded in nine EU countries, according to their country of origin (2003)



Source: IPTS. Our estimations from the NetReAct survey and Eurostat data.

4.1.2 Origin of postdoctorates

The number of postdocs in biological sciences in the U.S. was nearly 18,000 in 2002. In the EU-25, we estimated that there were approximately 19,000 postdoctorates in the field of life science in 2003. Most of them (5,700) were working in the UK (29.5% of the EU-25 total).

In 2002, 57% of the postdocs in biological sciences in the U.S. were temporary visa holders (10,100). In 2003, it is estimated that 25% of postdoctorates in life sciences working in the EU-25 were non-EU nationals (4,800).

Table 4. Number of postdoctorates in life sciences in the EU-25 and the U.S., according to nationality (2003)

	EU-25		U.S.	
	Numbers	%	Numbers	%
Nationals	14 600	75	7 787	43.4
Non-nationals	4 800	25	10 140	56.6
Total	19 400	100	17 927	100

Source: IPTS. Our estimations with data from Eurostat, NSF and the NetReAct survey.

We also find that 19% of postdoctorates were EU nationals working in a Member State of which they did not hold the nationality. Nearly 1,000 came from another European country outside EU and another 1,000 came from Canada or the U.S. Other countries contributed to about 3,000.

Table 5. Origin of postdoctorates in life sciences in EU universities (2003)

	EU		Non EU			Total
	Own country	Other EU country	Other European country (outside EU)	USA or Canada	Other country	
Numbers	11 000	3 600	1000	900	2 900	19 400
%	57	19	5	5	15	100

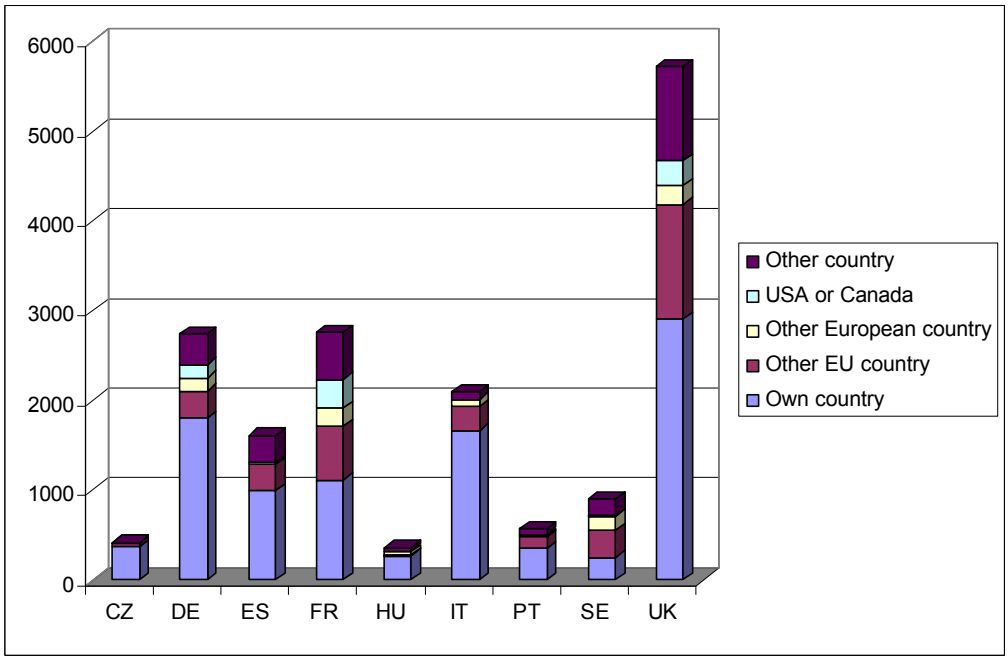
Source: IPTS. Our estimations with data from the NetReAct survey and Eurostat.

The UK attracts many postdoctorates from EU-25 origin. Indeed, we estimate that 1,300 postdoctorates from EU-25 countries (other than the UK) were working in the field of life

sciences in UK labs in 2003. France, the second country on the list, attracted only 600 postdoctorates from other EU countries.

Countries attracting the highest number of postdoctorates from North America rank like this: France (300 postdocs from this region), the UK (300) and Germany (150).

Figure 12. Number of postdoctorates in life sciences in nine EU countries, according to their country of origin (2003)



Source: IPTS. Our estimations with the NetReAct survey and Eurostat data.

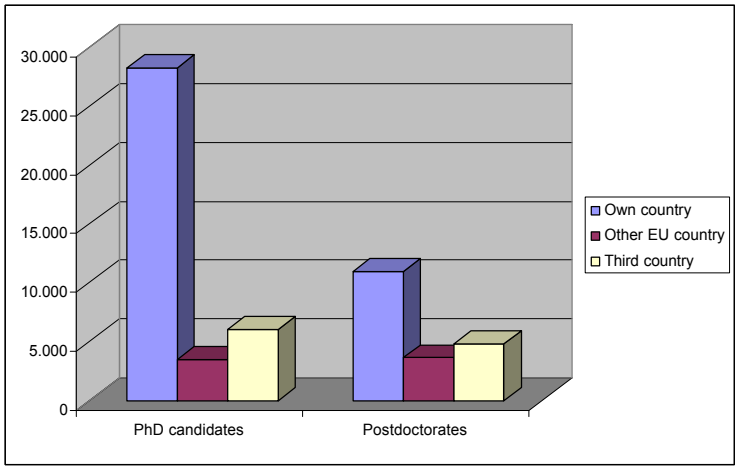
4.1.3 The total number of junior scientists in EU universities

The number of doctoral candidates in life sciences[9] in the EU25 is estimated to be around 38,000. 28,000 (75%) of them are not "internationally mobile", 4,000 (9%) are from another EU country and 6,000 (16%) are from third countries.

[9] This number has been estimated with Eurostat data, filling some gaps when data were missing and extrapolating the results at the EU level. The percentages given are slightly different from those of Table 3 because they are weighted by the number of doctoral candidates.

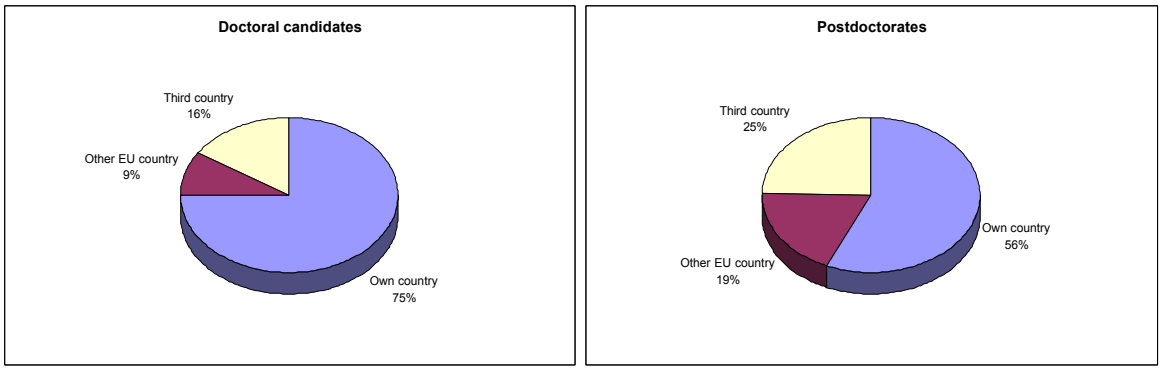
If we sum the number of doctoral candidates and the number of postdoctorates, we find that there are about 58,000 junior researchers in life sciences in the EU25. 39,000 are not "mobile" (69%), 8,000 are from another EU country (12%) and nearly 11,000 are from third countries (19%).

Figure 13. Number of junior researchers in life sciences in the EU25, according to nationality



Source: IPTS. Our estimations with the NetReAct survey and Eurostat data.

Figure 14. Percentage of junior researchers in life sciences in the EU25, according to nationality



Source: IPTS. Our estimations with the NetReAct survey and Eurostat data.

4.2 Destination of doctoral graduates and postdoctorates from EU universities

4.2.1 Destination of doctoral graduates

We proceed to similar estimations for the destination of EU doctoral graduates (about two years after doctorate completion) in combining Eurostat and NetReAct data. We make the assumption of a static framework: we based the calculations on the number of ISCED6 graduates in 2003 as it is not possible to calculate the number of doctoral graduates who have left since 2003.

76% of EU doctoral graduates in life sciences (this corresponds to about 6,700 doctoral graduates) continued to work in EU25 after receiving their doctoral degrees (64% stayed in the same country and 12% moved to another EU country). 24% went to a country outside EU25, this corresponds to about 2,000 doctoral graduates.

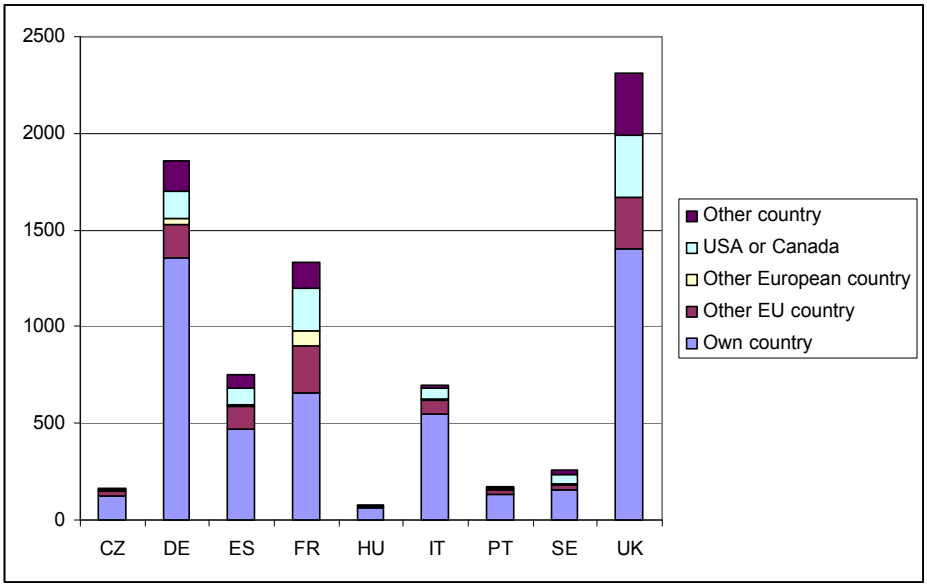
Table 6. Destination countries of doctoral graduates in life sciences from EU universities

	EU		**Non EU**			**Total**
	Own country	Other EU country	Other European country (outside EU)	USA or Canada	Other country	
Numbers	5 600	1 100	150	1 000	850	8 800
%	64	12	2	12	10	100

Source: IPTS. Our estimations with data from the NetReAct survey and Eurostat.

About 1,000 (12%) went to the United States or Canada. Among them, about 300 came from the United Kingdom, 200 came from France and 150 from Germany. These three first countries on the list accounted for about two thirds of the emigration of EU25 doctoral graduates in life sciences towards the USA and Canada.

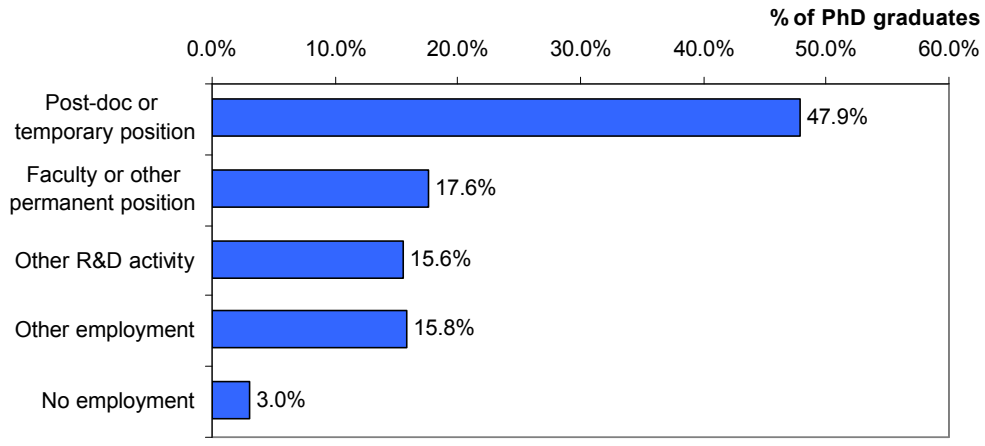
Figure 15. Destination countries of doctoral graduates in life sciences from EU universities



Source: IPTS. Our estimations with the NetReAct survey and Eurostat data.

In the NetReAct survey, information was collected on the activities of the former doctoral graduates. About 48% of doctoral graduates have started a post-doc or another temporary position in R&D, 18% have obtained a faculty or another permanent position and 16% have engaged in another R&D activity. 16% of them have another type of employment (outside R&D) and 3% are unemployed.

Figure 16. New activity of doctoral graduates of EU universities



Source: NetReAct survey.

In combining destination countries, new activities and organisations, it is found that doctoral graduates who stay in universities or go to non-university public research organisations often continue with a post-doc in their home country. The USA, Canada and other EU member states are also preferred destinations for post-docs. A smaller percentage of the graduates obtain a faculty or other permanent position, usually in their home countries.

4.2.2 Destination of postdoctorates from EU universities

58% of the post-docs working in the EU continued to work in the same country in which they had worked before and 18% went to another EU Member State. 24% went outside EU (4% went to another European country outside EU, 8% to the U.S. or Canada and 12% to another country.

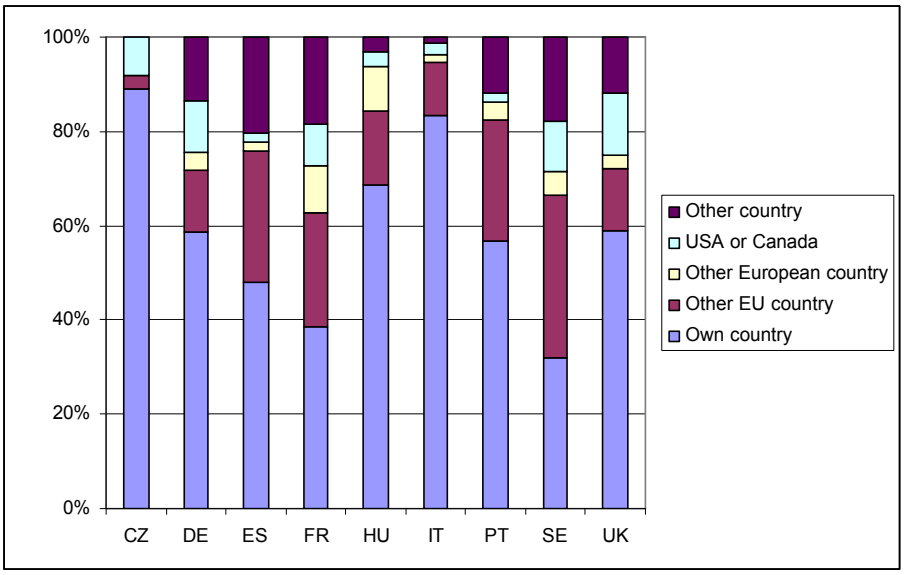
Table 7. Destination countries of postdoctorates from EU universities

	EU		Non EU			Total
	Own country	Other EU country	Other European country (outside EU)	USA or Canada	Other country	
	11 200	3 500	800	1 600	2 300	19400
%	58	18	4	8	12	100

Source: IPTS. NetReAct results.

The number of post-docs leaving the country where the former post-doctoral research position was, is particularly high in France, Sweden and Spain. French and Swedish post-docs are overrepresented in all other country categories. French, Swedish, German and British post-docs often chose the USA or Canada as a new destination. Spanish, French and Swedish post-docs frequently move on to other countries.

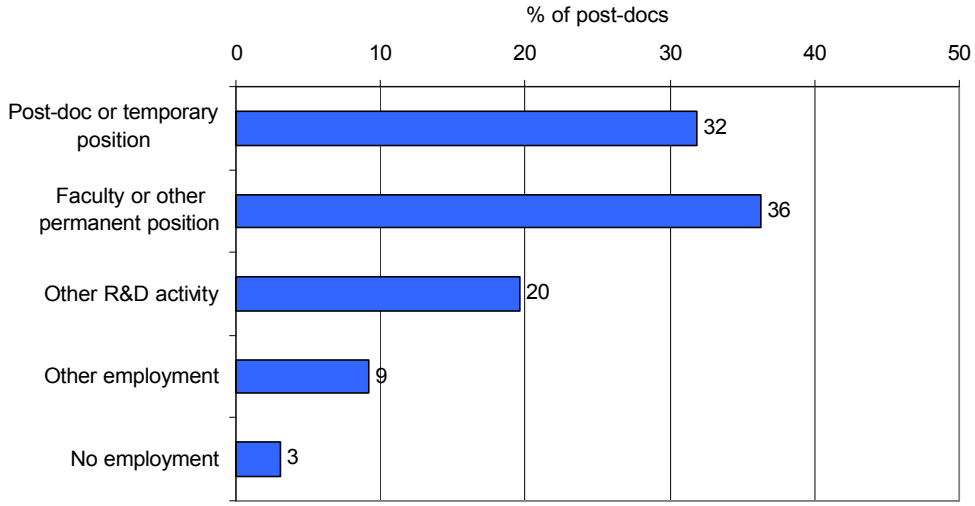
Figure 17. Destination countries of postdoctorates of EU universities (%)



Source: IPTS with NetReAct data.

One third of postdoctorates who have left the teams had continued a post-doc or other temporary position, another third had obtained a faculty or other permanent position and 20% engaged in another R&D activity. Only 9% had taken a different kind of employment outside of R&D and 3% had had no employment after leaving the team.

Figure 18. New activity of postdoctorates of EU universities



Source: NetReAct survey.

In combining destination countries, new activities and organisations, it is found that postdoctorates who stayed in universities or went to non-university public research organisations often continued with a post-doctoral or temporary research position in their home country. The USA, Canada and other EU member states were also preferred destinations for post-docs. A similar percentage of the post-docs obtained a faculty or other permanent position, usually in their home countries; some of the post-docs got these permanent positions in other countries outside of Europe.

5 Assessment and validity

One has to keep in mind that these results are broad estimations of the labour market of young scientists in life sciences. Questions have to be addressed to check the validity of the results.

5.1 NetReAct: an innovative and promising approach

Some uncertainties and limitations appear in the NetReAct methodology.

The research team is the basic unit of analysis of NetReAct, defined as a team or group of people who work together on related research topics within a university or other research establishment and is recognised from outside as a separate entity. The team members can be employed by different organisations but they work in one location. In some cases, especially in some countries, the application of this definition for the identification of teams is not obvious however, even if various ways have been used to identify them (International Handbook of Universisites and internet searches).

The distinction of university from non-university research teams is not evident in a number of cases. A number of limitations of websites appeared, in particular in Southern and Central Eastern Europe. Contradictory or unclear information have been found in some cases. A more general question arises about webometrics. It is certainly a promising tool but the methodology may have to be further tested and refined in the future.

The field of life sciences is not easy de define. The following disciplines have been included: biology, botany, zoology, ornithology, entomology, microbiology, bacteriology,

biochemistry, biophysics, genetics and toxicology. Clinical medicine, veterinary sciences and agriculture have been excluded.

The heads of units have responded to the questionnaires. The definition and identification of team leaders are not obvious however and a certain level of incertitude is probably associated with the concept. Contact details were also difficult to obtain in some cases. Moreover, it is likely that the knowledge they have is more or less precise depending on the questions that are addressed, especially when questions are related to their former doctoral students and post-doctorates.

In the questionnaire, some questions may pose a number of problems. The definition of postdoctorate (vs. other temporary research positions) is not that obvious even if in the field of life sciences it is likely that this concept is well-known and international. Similarly, permanent/tenure/open-ended contracts may have different signification in the different countries.

5.2 Assessment and validity of the results

To check the validity and representativeness of NetReAct results, an “internal” and “external” assessment has been done.

The “internal” assessment has consisted in a comparison of various characteristics of the NetReAct responses with the characteristics of the NetReAct sample. It has been done, according to:

- Inlinks. It appears that mean inlinks for non responses and for the sample are not statistically different (except for IT).
- Staff composition of the teams:
    - Mean group sizes and mean number of doctoral students for non responses (retrieved from the web) and from the sample are not statistically different.
    - Mean number of postdocs: it is found only slight difference for PT and SE.
    - Gender of the team head: no difference statistically significant is found except for DE and ES.

The general conclusion that has emerged is that the representativeness is generally good.

The external assessment has consisted in a comparison of NetReAct results with some national statistics such as the number of doctoral candidates and various characteristics of different populations. However, as many results of NetReAct are new and as the population identified is specific, it is difficult to carry out this assessment.

Using NetReAct results on the one hand, and Eurostat data on the other, we found that the number of doctoral candidates is correctly estimated for ES, IT, PT, UK and FR. However for SE and NO the estimation seems to be less satisfactory.

We also tried to compare NetReAct results with various French data.[10] More precisely, we compared statistics on doctoral candidates from NetReAct and French data from Céreq and the Ministry of Higher Education and Research, and we found that:

- The mean age seems to be correctly estimated.
- The gender distribution seems to be correctly estimated.
- The distribution of doctoral candidates according to their countries of origin seems to be correctly estimated, at least as far as broad groups of countries/regions are concerned.
- The main disciplines and funding of doctoral thesis has proven to be difficult to compare as classifications are different in NetReAct and in French data, and no clear conclusion has emerged.
- The labour market prospects after completion of the doctorate was difficult to compare. However, the unemployment rate and the proportion of employment outside R&D seem to be under-estimated in NetReAct.

Finally, when combining NetReAct and Eurostat data, the extrapolation at the EU level seems to be legitimate as the number of doctoral graduates in the 10 countries sample accounts for

[10] This comparison is difficult however. The dates of surveys are different, the populations are certainly not fully comparable, the time of observation are different etc.

87% of the EU25 total provided by Eurostat. However, incertitude remains about the representativeness of the 10 countries when disaggregating by some variables. Finally, the error margins are likely to be quite high as usable responses represented only 6% of the initial research population.

6 Conclusion

This paper studied the origin and destination of doctoral graduates and post-doctorates in life sciences from EU universities and gave some elements of comparison with the United States, with a combination of three sources of data (Eurostat, the NetReAct survey and U.S. NSF).

It has been found that the number of doctoral graduates in life sciences in the EU is higher than in the U.S. (9,000 against 6,000) but the proportion of foreigners is lower in the EU (17% against 29%). The number of postdoctorates in life sciences is more or less equivalent in the EU and the U.S. (19,000 against 18,000) but the EU to attracts less foreign postdoctorates than the U.S. (25% against 57%). 76% of doctoral graduates in life sciences from EU universities continue to work in the EU after graduation whereas 12% go to the U.S. or Canada, and another 12% go to another country. For postdoctorates from EU universities, percentages are more or less the same (76% stay in the EU, 8% go to the U.S. or Canada and 16% to another country).

A number of uncertainties and limitations have been identified, notably related to the methodology of the survey (e.g., identification of research teams, the life sciences field and the heads of units). However, the approach is innovative and promising.

The only way to have detailed and more precise information on the careers of young scientists in Europe would be to follow a cohort of doctoral graduates over a few years. However, the cost of the implementation of such a survey is rather high, especially if implemented in many countries, and it is rather long to produce results.

Another supplementary solution is to develop a more qualitative work[11] to address specific issues related to the career and mobility of doctoral graduates and postdocs, and notably to study their own experience on these subjects.

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[11] Similar to the study of Dedieu and Musselin (2004) in the French case.

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