Net ReAct

The role of networking in research activities

Deliverable 1.3

Doctoral students in the life sciences

by

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Table of contents

Executive Summary

General purpose and approach of the project

The "The role of Networking in research activities" (NetReAct) project is designed to capture, describe and analyse the strategies, patterns, dynamics and impact of networking in research activities in the life sciences in 10 European countries. The objectives are as in the Tender Specifications, specifically to develop and apply methods to shed light on current research collaboration behaviour of European universities, in particular in respect of the mobility of ideas and of personnel (brains) and in doing so:

- to assess the dynamics of universities' networking activities in respect of other universities, of public and private research bodies and
- to measure the capacity of universities and their laboratories to attract doctoral students and post-doctoral staff from other geographical areas.

The main unit of analysis in NetReAct is the research team or research group. We understand as a research team a group of people, scientists and non-scientists, which work in the same location for a longer time period to produce new scientific knowledge. The group of people is part of one or several larger organisations (university, department, school etc.), but at least some of its members are employed by a university. Also, the team is recognized from the outside as a separate entity.

The project uses an empirical approach that rest on three main pillars: a questionnaire-based survey targeted principally at heads of research teams to collect data on the doctoral students and post-docs at these institutions as well as further covariates which are supposed to influence research productivity; bibliometric data (publication and citation statistics) taken from the Thomson-ISI database to assess the levels of collaboration and output produced by these institutions, and webometric data (hyperlinks) collected from the internet to evaluate the position of these institutions in the life sciences networks.

The present deliverable D1.3 provides a first descriptive analysis of the responses to the survey of life sciences research teams focussing on three issues:

- an evaluation of the representativeness of the survey responses for the broader research population,
- a very general description of the distribution of the dataset by country, scientific discipline, age and size of the responding teams,
- a more detailed analysis of the survey responses on PhD students and graduates.

The NetReAct Survey

The identified research population consists of more than 7,700 teams from 359 universities (see table 1). We found more nearly 1,600 teams in the UK and more than 1,300 teams in France and Germany. Relatively few teams – between 170 and 230 – were found in the smaller countries Portugal, the Czech Republic, Norway, and

Hungary. Sweden has a relatively large life sciences sector with 650 teams. The average number of life sciences teams per university varies from more than 30 in the Nordic countries to only 15 in Portugal and the Czech Republic. Overall 1,773 teams or 23% of the research population were selected for the sample and addressed in the survey.

One of the purposes of the NetReAct project is to test the feasibility of the chosen approach to collect data on young researchers in science. The preparation and realisation of the survey taught us several lessons:

1. The identification and retrieval of research teams was only possible through time consuming searches of web pages in the university domain and manual copying-and-pasting of the relevant names and URLs. It was difficult in both large and small countries: the sheer size of the university-based life sciences in the UK, Germany, and France as well as varying institutional structures made it difficult to identify and collect all teams affiliated to universities. In some cases, in particular in Eastern and Southern Europe and in smaller and less known universities, the web pages were not very informative and did not always go down to the level of research teams. Moreover, in these little developed web presentations, links tended to be broken and the provided information was frequently outdated, incomplete or simply false. In these cases, it was very difficult to get a reliable picture of the research activities in the life sciences through the web.

2. In spite of these weaknesses, the approach proved to be successful. Nearly half of the teams included in the sample showed a measurable response to the survey and 26.4% of the teams entered the dataset with a usable questionnaire. Though the questionnaire was not translated into the mother languages and sent out in English, a negative effect on the response rates could not be detected. Moreover, a comparison between non-responding and responding teams in the dataset for a diverse set of structural variables – country, inlinks to the homepages, team size, numbers of PhD students and post-docs, gender of the team leader – did not provide evidence on any general bias. The dataset can be assumed to constitute a representative selection of the much larger research population.

3. A comparison of the staff data collected from the World Wide Web with the survey-based staff data indicated that the data from both sources is similar. Not only total staff numbers, but also the numbers of PhD students in both sources correlate: the Pearson correlation coefficient between both data series is 0.68 and highly significant. According to the web the average number of PhD students per team was 5.0 and according to the survey it was 4.6 – though both data series do not refer to the same point in time. However, on the web information on doctoral students could only be found for 259 out of the 468 teams (55.3%) and the available information for this personnel group is usually very limited, mostly just the name and the position.

4. A particular concern prior to the realisation of the survey was whether it would be possible to obtain information for the beginning of the year 2003, more than 2 years before the survey. Merely 50 respondents (6.2% of the responses and 2.8% of the

sample teams) stated that they did not have responsibility for a research team at the beginning of 2003. Hence, the reduction of the dataset according to this time lag between the realisation of the survey and the target-date is negligible overall; only in Norway the fluctuation between 2003 and 2005 seems to have been very high. Of course, it remains uncertain, whether all respondents really filled in the questionnaire for the target-date. It was frequently repeated in the questionnaire, but we have no way of verifying this.

5. The survey results also answer another question, namely whether it would be possible to obtain rather detailed data on individual PhD students and post-docs working in the teams (see D1.1, p. 70). The tables were not always filled out entirely and the respondents left open the questions they did not know for sure. But, for instance 426 team leaders provided information on the countries of origin of their PhD students, which is more than 90% of all teams in the dataset; and among the missing 42 teams for this variable are a number of teams which did not have any PhD students in 2003. In general, data on more than 1,500 PhD students working in the teams in 2003 and more than 1,400 students who left the teams since 2003 were provided by the team leaders.

6. These results also confirm the choice of the level of analysis, namely the lowest possible level (above individuals) of research teams. Not only were the team leaders able to fill in the questionnaires and provide the required answers, but the analysis of the results (so far on PhD students and graduates) produced a plausible and meaningful picture of life sciences teams. The team level seems to be superior to university level, too. Though we did not obtain any original data from university administrations and our university level analysis is merely based on limited data for a small set of universities, the aggregation clearly seems to conceal differences rather than reveal them. Moreover, the variations across teams affiliated to the same university are large making an identification of trends at this level nearly impossible.

All countries are sufficiently represented in the dataset. The largest share of teams in the dataset comes from the UK, namely 16.5% of the teams; more than 10% of the teams are from Germany, France, and Italy and each of the other six countries contributes between 6 and 9% of the teams. In regard to the main scientific discipline of the team we find an emphasis on biosciences. Approximately half of the teams are younger than 10 years and half of them are older. The average size of the teams in the dataset is 11 members, and three quarters of the teams have less than 20 members.

PhD students working in the teams in 2003

Doctoral students were the biggest staff group in life sciences research teams. Nearly 3 out of 10 team members were doctoral students and the teams in the sample employed on average 4.6 PhD students. The numbers of doctoral students per team vary across the countries in the sample, but there are no clear divides – like North-South, old-new member state, big-small country etc. – to be seen. Taking the age of the team, we find that teams younger than 5 years tended to have fewer students than older teams. In addition, large teams with 50 or more team members had fewer PhD students than smaller teams. However, this might be due to a misunderstanding on the side of the respondents who provided information for entire departments or institutes and not teams, as requested. Departments usually employ overhead staff (e.g. administration, library, joint laboratories etc.) which would inflate the denominator in the ratio of PhD students to total team members.

Several characteristics (age, gender, main discipline of doctoral research, country of origin and last degree, and sources and duration of funding) of up to five doctoral students per team were differentiated by country, main discipline of research, age and size of the team. The most important results can be summarised as follows:

- Doctoral students in the life sciences in the ten sample countries were on average 27.4 years young. The age was higher in the Nordic countries of the sample and lower in the UK. It was also higher in biomedicine and lower in the neurosciences.
- The majority of PhD students for which information was provided were female: 820 out of 1,553 (52.8%). In Portuguese and Italian research teams more than 60% of the PhD students were females, whereas in British teams there were more males than females. Males were also overrepresented in biomedical teams and teams with a major focus in other sciences (outside of the life sciences) and in small teams of less than ten members. Females were overrepresented in the neurosciences and in teams with 10-29 members.
- A lot of PhD research in the sample countries was done in biology and the biosciences. Practically every country is well represented in both disciplines. Biomedical research was also present in every country, but more than 25% of the PhD students studied for a PhD in this discipline in the UK. Doctoral students in biomedicine also work more often in multi-disciplinary teams than doctoral students in the other disciplines. PhD research in the neurosciences was important in France, Hungary, and Germany.
- More than three out of four PhD students studied for a PhD in their country of origin, and nearly 80% in the same country in which they graduated. In general, the figures for country of origin and country of last degree hardly differ. The majority of foreign born (or educated) PhD students in the sample countries had come from another EU country or another country outside of Europe. More students from Romania (30 students, or 1.8% of all PhD students) or China (22 students, 1.3%) studied in the ten countries than from the United States (17 students, 1.0%). Students from abroad could be found particularly in the UK, Sweden, and Germany. The “sending countries” differed: foreign life sciences PhD students were coming to Germany in particular from European countries outside of the EU, and to the UK and Sweden from all over the world. The country-related diversity of PhD students was lowest in Italy, Portugal, Czech Republic and Hungary. Foreign students were recruited especially by teams in the biosciences. As a rule, they also rather worked in older – and presumably more established – teams.
- PhD research was to 30% funded through university budgets and to more than 50% through other public sources. The importance of university versus other public

funding was reversed in Italy, the Czech Republic, and Hungary. University funding was more important for younger and smaller teams. Industry funding, self-funding (by the student) and other sources were generally of low importance. Only in France and the UK industry funding of PhD students was a little bit more common. Funding periods were usually longer than three years, and short term funding of less than one year was negligible.

PhD students graduating from the teams

In addition to data on the students that were studying in the teams at the beginning of 2003, we also obtained data on the teams' PhD graduates. Nearly half of the graduates continued to work in science on temporary positions. Fewer obtained permanent positions, worked in private sector R&D or continued on positions unrelated to research. According to the knowledge of the team leaders 3% did not find any employment after their PhD. Across all ten countries two third of the PhD graduates remain in the same country in which they obtained the PhD. The USA are a much more important destination for PhD graduates than source of PhD students. In particular high percentages of Swedish and French graduates have obtained new positions overseas.

The trajectories of PhD graduates clearly differed across countries. Whereas the typical Hungarian PhD graduate has obtained a faculty or post-doc position at a Hungarian university, French graduates more often have joined a non-university research organisation or left the country and sought a new job abroad. A sizable fraction of German graduates has moved on to research or other employment in the private sector in Germany.

What do these trajectories imply in regard to the fulfilment of the implicit contract between team (leader) and PhD student? We found that German, Swedish and Czech PhD graduates often have left science. They have taken jobs in the private sector and outside of research instead. This might indicate that public science cannot absorb all the PhDs and meet the career expectations of the PhD students in these countries. This, indeed, would indicate that a problem in regard to the implicit contract exists. The comparatively large percentages of non employed graduates in Germany and Sweden support this reading. However, a different explanation would be that conventions in regard to the role and value of a PhD might differ across Europe and that in the mentioned countries a PhD degree is often considered as the ticket to a career in industry. We cannot definitely answer this question, as a closer inspection of the motivations of PhD students would be required. However, the ongoing analysis of post-docs (WP 3) should produce some further results on their professional trajectories which can be compared with the findings on PhD graduates.

Recruitment of PhD students

Another chapter investigated the factors influencing the recruitment of PhD students from two perspectives: the attractiveness of the teams for PhD students and the attractiveness of applicants for open PhD positions.

In regard to the attractiveness of life sciences teams, the team leaders highlighted the role of the team's scientific reputation for obtaining highly qualified PhD candidates. Though it would have been better to ask the PhD students themselves, what they judge important, we think that the responses are trustworthy as the team leaders once were PhD students, too. In addition to the scientific reputation the quality of the PhD education plays a major role, whereas industry contacts were hardly rated as important.

The most desired property of applicants is a high degree of motivation and commitment. All other characteristics are considered to be less important, though some still receive a high importance ranking, like whether applicants are expected to fit into the team, their grades, discipline, previous affiliation or recommendations from colleagues.

The appraisals of team and applicant characteristics differ by country. For instance, recommendations play a more pronounced role in France than in the other countries; local candidates and previous knowledge of the applicants are less important in the UK, where PhD students are more mobile and more international than in the other countries. Some of the appraisals also tend to vary between young and old teams as well as between small and large teams.

In all countries except for Germany more than half of the teams were associated to a graduate school. However, this association does not seem to entail any specific consequences in regard to the number or structure (internationality) of PhD students.

University level evidence

The university level analysis used the information for roughly 60 universities for which more than three team leaders provided team information. Of course, it is daring to extrapolate the results for three teams to a population of more than 20 teams per university. However, we employed as much care as possible and looked at both, arithmetic means and standard errors.

As expected, the results reproduce in many ways the patterns found at team and country level. Due to large variances of the chosen indicators within universities it is rarely possible to identify valid and reliable differences between universities. Few universities seem to have a uniform strategy on the composition of research teams and the role of doctoral students in these. For the universities at Heidelberg, Coimbra, and Uppsala and the KTH Royal Institute of Technology Stockholm we found large and for the Milan and Cambridge universities small shares of PhD students in the life sciences teams.

The second step of the analysis looked at the country composition of the doctoral students in the universities. The most international teams were at the German universities of Freiburg, Tübingen and Heidelberg, the University of Milan in Italy, Bergen University in Norway, and nearly all Swedish and British universities (in particular Cambridge and Liverpool). The teams responding to the survey from the Czech Academy of Sciences, the Université Paris-Sud, the Hungarian universities of Debrecen, Pécs, and Veszprém and the Italian Università di Bologna did not have any doctoral students from other countries. US American and Canadian students were particularly frequent at teams from the universities of Oxford and Dundee in the UK and the Université Montpellier II in France. Comparing this with the previous result on team structure, we find that universities with few PhD students per team might be just as international as universities with many PhD students (e.g. Milan versus Heidelberg).

If we look at the source of funding of PhD students by university we do not see a clear pattern either. It is interesting to note that those universities who obtained funding for the PhD students from industry are usually not those with large shares of PhD students or with many PhD students from abroad. However, at the current point we do not know whether these are the successful outperformers or rather the underperformers when it comes to scientific publications and citations. This is something that will be investigated further in the work of WP 4.

Further lines of work

The deliverable provides a descriptive overview of the doctoral students in European life sciences research teams. It does not yet carry out any multivariate analyses with data on other team members like the team leader or post-docs which were also collected in the survey; bibliometric data on the publications of these teams and the citations of their publications; or webometric data on the hyperlinks pointing to the teams' web presentations. This kind of analysis is possible with the available data and it will constitute the major part of the work to be done in WP 4. Several issues on PhD students can be discussed in work-package 4:

1) In D1.1 (p. 40) three hypotheses were formulated on the role of doctoral students in the life sciences:

> H2.1: Research teams that realise a division of labour between junior and senior scientists have higher research productivity than teams that don't realise a division of labour.
>
> H2.2: Research teams with many PhD students do not have higher research productivity than teams with few PhD students.
>
> H2.3: The research productivity of teams fulfilling the implicit contract with PhD students is higher than the research productivity of teams that break it.

These hypotheses can be investigated by using the data on the overall composition and age structure of research teams (division of labour between junior and senior scientists), the share of PhD students and the professional trajectories of PhD graduates.

2) Moreover, the available data also permits to explore several further issues related to doctoral students:

- Are the structures of PhD students and post-docs related, for instance do teams with a heterogeneous set of doctoral students (in regard to country, discipline, gender) also have a heterogeneous set of post-docs?
- Are teams which are good at attracting doctoral students from abroad also good at attracting post-docs?

- What is the relationship between certain characteristics of the team leaders (country of birth, age, gender, discipline, recognition) and the doctoral students in their teams? What characteristics favour the attraction of PhD students from abroad?
- How are the characteristics of the doctoral students in a research team related to its productivity and collaborative relationships with other teams?
- How are the characteristics of the PhDs graduating from a research team related to its productivity and collaborative relationships with other teams?

3) Integrating the variables on doctoral students, post-docs, and collaborations typologies of teams can be constructed which then can be further analysed in regard to their research performance.

1 Introduction to the NetReAct project and the deliverable

1.1 Overall aim and structure of the project

The “The role of Networking in research activities” (NetReAct) project is designed to capture, describe and analyse the strategies, patterns, dynamics and impact of networking in research activities in the life sciences in 10 European countries. The objectives are as in the Tender Specifications, specifically to develop and apply methods to shed light on current research collaboration behaviour of European universities, in particular in respect of the mobility of ideas and of personnel (brains) and in doing so:

- to assess the dynamics of universities' networking activities in respect of other universities, of public and private research bodies and
- to measure the capacity of universities and their laboratories to attract doctoral students and post-doctoral staff from other geographical areas.

The work is structured along four work-packages:

- Work-package 1: Characterisation of doctoral students
- Work-package 2: Bibliometric measures of networking activities and of their impact
- Work-package 3: Characterisation of post-doctoral training
- Work-package 4: Analysis of the datasets

The research objectives will be pursued with different methodological approaches of data collection (and interpretation):

- a *questionnaire-based survey* targeted principally at heads of research teams to collect data on the doctoral students and post-docs at these institutions as well as further covariates which are supposed to influence research productivity,
- *bibliometric data* (publication and citation statistics) taken from the Thomson-ISI database to assess the levels of collaboration and output produced by these institutions, and
- *webometric data* (hyperlinks) collected from the internet to evaluate the position of these institutions in the life sciences networks.

The different data sets will be combined in work-package 4 to develop profiles of life sciences research teams and analyse their research productivity. Work-packages 1 and 3 mainly rest on the data gathered in the survey which will be described subsequently. Bibliometric and webometric methods are described in the deliverables of work-package 2.

The data collections and analyses of the NetReAct project are carried out for 10 countries as required according to the tender specifications: France, Germany, the UK, Italy, Spain, Portugal, Sweden, Norway, Hungary, and Czech Republic.

The life sciences disciplines included in the analysis were originally based on two different classifications: (1) the ISCED97 classification and (2) the K.U. Leuven-IRO Subject Classification. In line with the tender specifications, the ISCED97 classification was used to identify the scientific disciplines of research teams and their members (heads of the teams, PhD students, post-docs) from an education-related point of view. The exploratory interviews taught us that the ISCED 1997 classification is not really in line with the self-perception of team leaders in the life sciences (see NetReAct deliverable 1.1, p. 60). Hence, we chose to use the K.U. Leuven-IRO classification for identifying the research fields of the research teams in the survey and the bibliometric analysis. The K.U. Leuven-IRO classification uses a broader concept of the life sciences and accounts for the fact that life scientists do not publish only in journals of their core fields, but also in journals of related and neighbouring fields. Three major fields – Biology (Z1-Z5), Biosciences (B) and Biomedical research (R) – cover the life sciences as defined in ISCED97.

1.2 Research teams as the basic unit of analysis

The main unit of analysis in NetReAct is the research team or research group. We understand as a research team a group of people, scientists and non-scientists, which work in the same location for a longer time period to produce new scientific knowledge.[1] The group of people is part of one or several larger organisations (university, department, school etc.), but at least some of its members are employed by a university. Also, the team is recognized from the outside as a separate entity.

The definition uses different restrictions in regard to location, time, and people. The geographical restriction may be somewhat counterintuitive and against the growing tendency to virtual collaboration facilitated by the internet and other computer networks. It was nevertheless necessary in order to clearly meet one of the main objectives of the study which lies in juxtaposing the effects of group features and inter-group collaboration on research productivity. The inclusion of non-collocated and virtual members in the groups would have made it difficult if not impossible to distinguish clearly between external group members and collaborators. For the same reason, visiting scientists and guest workers were not included in the research teams if they stayed less than six months.

We do not limit the research group to people that are employed by the same organisation or to publishing authors only. Limiting the teams to scientists employed by one institution would force us to ignore the open organisational approach to research groups taken in some countries. For instance, in France scientists with different organisational affiliations, usually universities and non-university research organisations, join efforts in so called mixed research teams. However, to limit the

[1] See on other possible ways of defining research groups: NetReAct deliverable D1.1, pp. 15-16.

overall scope of the analysis and in line with the Tender Specifications we only selected teams which were affiliated to a university. As one of our main purposes is the evaluation of the role of doctoral students and post-docs in research groups, we could not limit the groups to co-authors. In particular doctoral students participate in research teams and carry out the labour-intensive groundwork, but they might not publish before finishing their doctoral thesis. Whether graduate students at master level, often also called research students, should be included, was also an open issue. Though their main purpose is to learn and broaden their own knowledge and not to produce new knowledge, they might render valuable research assistance in some groups which would be false to ignore. Hence, we assessed their numbers and the empirical analysis of WP 4 will tell whether they have any measurable effect on the group's performance.

Research teams as we understand them might but need not coincide with what Joly and Mangematin (1996), Laredo and others (1999, 2001) defined as laboratories. Bigger labs which consist of several units or teams are not included entirely, but only with one or several of their teams. This selection of the smaller unit was mainly due to our topic and empirical approach: as we requested detailed information on doctoral students, post-docs and collaboration activities, we had to address informants with sufficient knowledge on these issues. Furthermore, Joly and Mangematin (1996) point out that the logic which governs the relationships between science and industry varies between research teams:

"Laboratories are often composed of one or two research teams which have differing types of relationship with their environment. Industrial relationship logics therefore vary within the laboratories." (Joly & Mangematin, 1996, p. 916)

This should also apply to the relationships between research teams from science – it would be daring to assume that all teams within a lab have the same collaboration relationships and degree of integration into scientific networks. Therefore, the team level is essentially the more appropriate one for our type of analysis.

Research teams are not isolates, however, but they are linked to other groups through research networks, i.e. the informal and loose interactions and relationships which exist between the heads and principal investigators of research teams (see NetReAct deliverable D1.1, pp. 16-18).

1.3 Contents of this deliverable

The present deliverable D1.3 provides a first descriptive analysis of the responses to the survey of life sciences research teams focussing on three issues:

- an evaluation of the representativeness of the survey responses for the broader research population,
- a very general description of the distribution of the dataset by country, scientific discipline, age and size of the responding teams,
- a more detailed analysis of the survey responses on PhD students and graduates.

Though several of the issues discussed in the NetReAct deliverable D1.1 are revisited in this deliverable, it is not an exploration of the 22 hypotheses formulated there (see D1.1. pp. 6-8 for a summary). This is not yet possible, as the bibliometric data collected in WP 2 are a necessary ingredient to this. This final step will be carried out in workpackage 4. The present deliverable rests mainly on the survey results and in particular on the responses to the questions on doctoral students.

Chapter 2 first recalls the work done within WP 1 to generate the research population and sample of life sciences research teams. It reproduces some basic statistics on both, the population and the sample, as the ongoing work in WP 1 after the delivery of D1.1 led to slight changes (enlargements) of both. Second, some basic survey statistics are shown which might be useful in the planning of future surveys in this field or with a similar layout and objectives. Third, the survey results are analysed from a statistical perspective in order to assess the representativeness of the survey responses. The available characteristics of responding and non-responding teams from the sample are compared. The findings are generally very positive and supportive of the representativeness of the survey responses.

In chapter 3 we provide a general overview of the survey results. In particular, we show the distribution of teams by country, scientific discipline, age and size. These variables are used in the remainder of the deliverable for structuring the responses and comparing different subgroups of teams. A comparison for the numbers of doctoral students and their shares among the total team personnel between different groups of teams is included in the second part of chapter 3.

Chapter 4 carries out a more detailed description of several variables for doctoral students built on the basis of the survey results. These variables refer to doctoral students working in the life sciences teams at the beginning of 2003, the PhD graduates of these teams, the factors influencing the attractiveness of life sciences teams for PhD students and desired characteristics of applicants for PhD positions. For each set of variables we show the responses for the entire dataset and we differentiate by country, main discipline, age and size of the team. These descriptions do not yet answer any of the hypotheses, of course, but they are necessary to obtain a good understanding of the structures of the dataset (for doctoral students).

Chapter 5 looks at the survey responses at a different level of aggregation, namely the university level. For a limited set of variables and universities – those from which three or more teams responded to the survey – we aggregated the responses and compared the results across universities. The results were, however, not too convincing and they provided nearly no additional insights to the team level analyses. Therefore, we did not engage in this effort to a greater extent.

At this stage of the research it does not make much sense to draw conclusions and a summary has been provided at the beginning of the deliverable. The last chapter therefore summarises some lessons learned during the realisation of the survey and the analysis of the data; it also gives an outlook on the further work that will be done with the survey results in work-package 4.

2 NetReAct survey on life sciences research teams

2.1 Research population and sample of the project

2.1.1 The research population

The primary statistical unit of analysis is the university-based research team. The identification of the population of life sciences research teams drew heavily on the International Handbook of Universities (International Association of Universities [IAU], 2003) and the internet as sources of information. The research population was assembled in three major steps of work:

1) The International Handbook of Universities was used to identify universities with teams in the life sciences.

2) From the websites of these universities we collected the names and URLs (WWW addresses) of the life sciences teams, searching for groups mentioned by the IAU and also navigating the university faculty/department structure to look for additional groups. The name and URL collection produced "hierarchical trees" which included the information on the faculties, departments, institutes and research teams.

3) The web pages of the sample teams (see below on the sampling) were submitted to a closer review when their addresses were collected. This led to the identification of further research teams which were subsequently added to the research population.

A particular challenge was the distinction of university research teams from teams of non-university research organisations and other tertiary education institutions (colleges). In most countries the exclusion of the non-university research sector was easy to implement, because the organisations appear as separate entities. For instance the institutes of the Czech Academy of Sciences, the German Max-Planck-, Fraunhofer and Leibnitz-Societies, the Spanish and Italian Research Councils (CSIC and CNR) are in most cases not included on university websites; and if they are included, they are clearly denoted as extra-university. Things are different in France: 85% of the CNRS research teams are in cooperation with universities and other research institutions and 45% of the INSERM laboratories are located in universities; many of these labs are run under cooperation agreements or they are actually mixed laboratories, so called "Unités mixtes de recherche (UMR)". Moreover, the temporary nature of the labs in France made the identification via the internet difficult, in particular if they were discontinued after the latest funding period. We opted to include these mixed teams, if a participation of university personnel was clearly discernible. This was applied in particular to the French case but also to other countries, when non-university and university personnel formed together a research team.

Other tertiary education institutions – in particular teaching-oriented colleges in the UK, university colleges in Sweden, and the *Fachhochschulen* in Germany – were generally not included in the research population. They are higher education institutions and in many cases they may even train PhD students, but they do not issue doctoral degrees themselves, and doctoral students play a different role than in “regular” universities. Hence, only research teams which are part of organisations issuing doctoral degrees were included in the population.

The research population thus identified consists of more than 7,700 teams from 359 universities (see table 1). We found more nearly 1,600 teams in the UK and more than 1,300 teams in France and Germany. Relatively few teams – between 170 and 230 – were found in the smaller countries Portugal, the Czech Republic, Norway, and Hungary. Sweden has a relatively large life sciences sector with 650 teams. The average number of life sciences teams per university varies from more than 30 in the Nordic countries to only 15 in Portugal and the Czech Republic.

Table 1: Research population of life sciences research teams by country

Country	No. of universities with life sciences research teams	No. of life sciences teams identified	Life sciences teams per university
CZ	11	173	15.7
DE	61	1,447	23.7
ES	48	896	18.7
FR	57	1,384	24.3
HU	10	214	21.4
IT	47	952	20.3
NO	6	199	33.2
PT	15	229	15.3
SE	15	650	43.3
UK	89	1,588	17.8
Total	**359**	**7,732**	**21.5**

Source: NetReAct (FHSO).

2.1.2 Sampling and sample characteristics

For the statistical analyses of work-package 4 an overall dataset of at least 300 research teams was considered desirable to secure sufficient variation. On the basis of a country sample of 10 countries this would consist of on average 30 research teams per country. Response rates of newer postal surveys in an academic environment measured between 25% and 50% (Barjak & Harabi, 2004; Bozeman & Corley, 2004; Fritsch & Schwirten, 2002; Laredo, 1999; Walsh, Kucker, Maloney, & Gabbay, 2000). As the questionnaire was quite long, asked for rather detailed and not always readily available information on doctoral students and post-docs, and the survey period fell into the holiday season, we expected a low overall response rate of 25-30%. We further assumed 5% of the returned questionnaires to be only partially filled and unusable and a rate of usable questionnaires of 20%. This required a sample of at least 1,500 research teams in order to obtain the minimum number of 300 usable datasets.

We employed a stratified, random sampling to obtain these 1,500 research teams which is briefly described in the following paragraphs (for a more detailed description see deliverable D1.1, p. 51-55).

1) In the first step, strata for sampling were built according to country and a simple importance indicator derived from the webometric analysis. Automatic hyperlink retrieval through the Google search engine produced the number of inlinks, or hyperlinks pointing to the homepages of the life sciences teams in the research population. The link numbers obtained were used for the stratification of the population according to the presence or impact on the internet. Based on previous research (Thelwall & Harries, 2004), we assumed that this presence is related to the scientific performance of the research teams.

2) As a second step we added the inlink data for each research team and ordered the teams of each country by inlink class and university. We thus obtained a list of teams with the most inlinked (= best performing) teams at the top. This served the purpose of having the best performing research teams in the life sciences included.

3) At the same time, some randomness was needed in order to guarantee that the data is representative at country level. Therefore, we calculated drawing probabilities which varied according to the inlink data. The drawing probability for the highest inlink class (> 10 inlinks) and all further link classes was defined in a way that secured a minimum number of 100 sample teams for the countries with small life science systems (NO, PT, HU, CZ), 150 for the countries with medium-sized systems (IT, ES, SE), and 200 teams for the countries with large systems (FR, DE, UK). The drawing probabilities per link class are based on a simple exponential function: $dp_i = dp^i$ (dp: drawing percentage, i: inlink classes 1-5).

4) The drawing probabilities were then used to draw the sample country-wise from the sorted lists of all research teams obtained in step 2. The drawing was done systematically from the beginning of the list to its end which aimed to guarantee a maximum representation of different universities in the sample.

This resulted in the sample as shown in table 2. Overall 1,773 teams or 23% of the research population were selected for the sample. The coverage varies notably across countries, however. For the countries with the smaller life science systems more than 50% – in Czech Republic and Norway more than 60% – of the research population are included. This percentage goes down to only 16.3% for France and 18-19% for Spain, Germany, UK, and Italy. University coverage is generally higher, of course. However, the average number of teams in the sample per university is only 5.8. Taking the expected response rate of 25-30%, we expected on average only 1-2 responses per university. This bears some consequences for the analysis at university level: it is only possible for the few larger universities in each country, but not for all 304 universities in the sample.

Table 2: Sample of life sciences research teams per country

Country	Universities included		Teams included		Teams per university
	No.	In % of population	No.	In % of population	
CZ	11	100.0%	119	68.8	10.8
DE	56	91.8%	271	18.7	4.8
ES	39	81.3%	164	18.3	4.2
FR	49	86.0%	225	16.3	4.6
HU	10	100.0%	108	50.5	10.8
IT	39	83.0%	186	19.5	4.8
NO	6	100.0%	122	61.3	20.3
PT	15	100.0%	123	53.7	8.2
SE	14	93.3%	148	22.8	10.6
UK	65	73.0%	307	19.3	4.7
Total	**304**	**84.7%**	**1,773**	**22.9**	**5.8**

Source: NetReAct (FHSO).

Table 3: Inlinks to the life sciences research teams in the sample by country[a]

Country	Inlinks per team	No website	Percentage of teams per inlink class					
			0	1-2	3-5	6-10	> 10	Total
CZ	2.0	3.4%	52.1%	25.2%	11.8%	6.7%	4.2%	100.0%
DE	10.7	1.1%	11.8%	15.9%	19.2%	21.0%	32.1%	100.0%
ES	3.0	17.1%	57.9%	18.9%	8.5%	9.8%	4.9%	100.0%
FR	4.3	3.6%	41.8%	28.0%	12.0%	9.8%	8.4%	100.0%
HU	4.1	3.7%	44.4%	27.8%	9.3%	6.5%	12.0%	100.0%
IT	2.1	12.9%	53.2%	21.5%	14.5%	8.1%	2.7%	100.0%
NO	6.0	0.0%	23.8%	32.8%	13.9%	9.8%	19.7%	100.0%
PT	9.1	15.4%	51.2%	13.8%	6.5%	7.3%	21.1%	100.0%
SE	8.0	3.4%	31.1%	27.0%	15.5%	7.4%	18.9%	100.0%
UK	7.6	3.3%	21.2%	24.4%	24.8%	14.7%	15.0%	100.0%
Total	**6.2**	**5.9%**	**35.7%**	**23.1%**	**15.1%**	**11.4%**	**14.7%**	**100.0%**

Source: NetReAct (FHSO & SCIT).

In table 3 we provide the link statistics for the teams in the sample. The average inlink figure per team was higher in the sample than in the research population (see deliverable D1.1, p. 55) which served the purpose of having the top performers in life sciences research overrepresented. On average, 6.2 hyperlinks pointed to the homepages of the teams in the sample – high average link numbers can be found in Germany, Portugal, the UK and the Nordic countries.[2] They are considerably lower in the other countries in the sample. For 6% of the teams in the sample we could not find a homepage. In

[2] The high average link number for Portuguese life sciences research teams is due to 21 teams from one university. The links to these websites are mainly internal links for navigational purposes. If these teams are excluded, the average inlink figure per team is reduced to 2.6.

particular in the Southern European countries these percentages are higher with 17% in Spain, 15% in Portugal and 13% in the case of Italy. The distribution over the five inlink classes shows again the North-South divide that can also be seen in the average link data.

When the addresses for the research teams in the sample were collected from the WWW, additional information on the personnel was added. This serves the purpose of comparing the respondents to the survey with the overall sample and checking for any bias in the responses (see chapter 2.2.3). The results are shown in table 4. The average size of the research team according to the WWW is 14.7 scientific and non-scientific workers, ranging from 10.2 in Portugal to 22 in Hungary. Across all countries each life sciences team trains 5 PhD students. In Italy, this number is significantly lower whereas it is higher in the Czech Republic, UK and Sweden. According to these figures sourced from the internet, PhD students approximately represent 30-35% of the total scientific and non-scientific staff. For nearly 700 or close to 40% of all teams in the sample the homepages also provided information on the post-docs working in these teams. We found 2.6 post-docs per team across the entire 10 country sample, with higher figures in the UK and Germany and lower figures in Italy, Czech Republic, Spain and France. However, it has to be noted that the figures on PhD students and post-docs are very much preliminary and only suitable for getting a vague overview of the sample structure. They were gathered from the World Wide Web, and even for those teams which provided them, we do not know, whether they are up-to-date and complete (probably in many cases they are not).

Table 4: Staff of sample teams by country (according to the WWW)

Country	Total scientific and non-scientific staff	PhD students[a]	Post-docs[b]
CZ	15.1	6.2	1.7
DE	16.8	5.5	3.2
ES	12.2	4.6	1.8
FR	17.8	5.0	1.9
HU	21.7	4.3	2.8
IT	10.2	3.2	1.5
NO	12.5	4.0	2.8
PT	11.0	4.6	2.2
SE	13.4	5.8	2.2
UK	13.0	5.9	3.9
Total	**14.7**	**5.0**	**2.6**
Valid N (% of sample)	**1,374 (77.5%)**	**954 (53.8%)**	**697 (39.3%)**

Source: NetReAct (FHSO).

2.2 Survey methodology, responses and representativeness

2.2.1 Survey methodology

NetReAct implemented a questionnaire-based survey to collect information on doctoral students and post-docs. This survey is also used to gather further information at research team level critical for progressing understanding of key hypotheses in the analysis and modelling of WP4. This information will help resolve spurious correlations and dismiss some important rival hypotheses when it comes to assessing the impact of collaboration and other networking activities on scientific output (WP4).

The questionnaire was developed in order to collect information on doctoral students and post-docs in the life sciences as specified in the tender, as well as some additional control variables. In particular it contained questions on (see annex 2 on the full questionnaire)

- The research group, its affiliation(s), research fields, overall personnel numbers and development since 2003,
- 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, including demographic and education-related information,
- Profiles of the heads of the research teams,
- Number of collaborating teams and motivations to engage in research collaborations,
- Publication lists or publishing scientists in a team as input to the bibliometric analyses of WP 2,
- The questionnaire itself as a test of the methodological approach.

Overall, the questionnaire was rather long, with 31 separate questions and many of them in the form of complex tables. In particular the respondents had to fill in some rather detailed information on doctoral students and post-docs with which not all of them were familiar (see NetReAct D1.1, p. 70). The questionnaire was drawn up in English. We assumed that this would not have any significant negative impact on the response rate, as English is the lingua franca of science and most scientists read and understand it well enough. Also, a recent survey among scientists in five disciplines conducted by one of the NetReAct partners did not show any major influence of the mother tongue on the response rates to an English language questionnaire (see Barjak & Harabi, 2004).

The data collection was carried out in two different ways:

1) A Word on screen version of the questionnaire was e-mailed to part of the sample with a request to return the completed questionnaire by e-mail.
2) An e-mail with a personalised hyperlink leading to an html (internet) version of the questionnaire was sent to the other part of the sample. The respondents were asked to fill in the questionnaire on screen and save it at the end.

In order to reduce non-responses an additional Word for print version was produced and offered to be sent out on request.

The survey approach was evaluated through a pre-test with 69 teams from UK, DE, and FR. The responses proofed the general feasibility of the approach and after minor corrections and changes of the questionnaire, the mailing started in the first week of July. Because of the holiday season the overall response period was extended to the beginning of September. From July to September the teams received up to three reminders asking for completion of the questionnaire. The goal of comparing the responses to the two different data collection methods cannot be carried out, however, as due to an error in the mailing of the first reminder all teams received a personalised link to the online survey.

2.2.2 Responses to the survey

Overall, out of 1,773 teams in the sample 773 (43.6%) showed a measurable response (see table 5). 962 teams had not responded till the closing of the survey (September 12, 2005). Of these 962 teams 34 (1.9%) had not received the questionnaire, because a correct e-mail address for the team leader could not be found through the internet.[3] Particularly high response rates of more than 50% appear for Portuguese, Italian, Norwegian, and Hungarian teams. Rather low are the rates for France, Germany, Spain and the UK.

Table 5: Responses to the survey by country (total sample)

Country	No response		Not deliverable		Response		Total N (sample)
	N	in %	N	in %	N	in %	
CZ	62	52.1%	2	1.7%	57	47.9%	119
DE	162	59.6%	4	1.5%	110	40.4%	272
ES	100	61.0%	1	0.6%	64	39.0%	164
FR	138	61.3%	8	3.6%	87	38.7%	225
HU	49	45.4%	2	1.9%	59	54.6%	108
IT	85	45.7%	3	1.6%	101	54.3%	186
NO	54	44.6%	0	0.0%	67	55.4%	121
PT	53	43.1%	1	0.8%	70	56.9%	123
SE	75	50.3%	0	0.0%	74	49.7%	149
UK	184	60.1%	13	4.2%	122	39.9%	306
Total	**962**	**54.3%**	**34**	**1.9%**	**811**	**45.7%**	**1,773**

Source: NetReAct survey.

[3] This number is quite small. However, in each of the mailings e-mails to previously seemingly working mail addresses were returned as undeliverable and errors could be corrected. Thus we assume that some additional delivery failure notes may have been suppressed by the sending or receiving mail servers and that the actual number of undelivered mails might be higher.

Around six percent of the respondents stated, that they did not have responsibility for a life sciences research team at the beginning of 2003 and that our questions were therefore not applicable to them (see table 6). In most cases these were young team leaders who had obtained this position within the previous two years, and in some instances we had contacted retired scientists. For Norway this share is notably higher than for the other countries which points to a considerable fluctuation of team leaders. In addition, 4.3% of the respondents refused to participate in the survey usually stating time constraints. Approximately 30% of the respondents looked at the questionnaire front page or even started to fill it out, but dropped out in the process and didn't enter the critical questions which would permit us to include the response in the analysis. Hence, across all countries 60% of the responses can be included in the NetReAct analyses. In other words, 26.4% of the respondents included in the original sample provided usable questionnaires.

Table 6: Usable responses to the survey by country

Country	All responses		Not applicable		Participation refused		Usable questionnaires	
	N	in %	N	in % of all	N	in % of all	N	in % of all
CZ	57	100.0%	4	7.0%	2	3.5%	30	56.6%
DE	110	100.0%	8	7.3%	9	8.2%	60	60.0%
ES	64	100.0%	2	3.1%	0	0.0%	37	57.8%
FR	87	100.0%	6	6.9%	3	3.4%	56	69.1%
HU	59	100.0%	3	5.1%	1	1.7%	34	61.8%
IT	101	100.0%	2	2.0%	0	0.0%	52	51.5%
NO	67	100.0%	10	14.9%	6	9.0%	37	58.7%
PT	70	100.0%	6	8.6%	1	1.4%	44	64.7%
SE	74	100.0%	3	4.1%	5	6.8%	41	60.3%
UK	122	100.0%	6	4.9%	8	6.6%	77	64.2%
Total	**811**	**100.0%**	**50**	**6.2%**	**35**	**4.3%**	**468**	**60.5%**

Source: NetReAct survey.

Neither in regard to overall responses nor in regard to usable responses does the language seem to play a role. The questionnaire was drawn up in English, but none of the response categories is particularly high for the UK. On the contrary, in regard to overall responses the UK is below the ten-country average.

2.2.3 Representativeness of the responses

For making valid statements on the situation of university life sciences teams, PhD students and post-docs in the sample countries it is crucial to have a representative set of responses, as the responses constitute only a small percentage of the entire research population (roughly 6%). In this section we compare the characteristics of the responses with the characteristics of the sample – which was drawn from the entire population at random including stratification by number of inlinks – in order to check the representativeness. First of all we can state that there is no significant bias in the responses by country, i.e. the total is representative for the ten countries (see annex table A-3).

Representativeness according to inlinks

The major influence on the drawing probability for the sample was the mean number of inlinks to the group's homepage. Therefore, representativeness in this respect is of key importance for the validity of the survey results and the possibility to generalise them for the entire population. The mean inlinks to the homepages are 6.1 for the sample teams without a usable response and 6.4 for the teams with a usable response (c.f. table 7). From a statistical perspective these means are not significantly different – both, the F-Test and the robust Welch-Test by far miss the significance threshold. Though for some countries the mean inlinks seem to differ between both parts of the sample (usable response and non usable response), e.g. Hungary, Norway or Portugal, statistically seen these differences are all random. Only for Italy we obtain a statistically significant difference between the mean values, however, at a very low level.[4] In general, we can state that the mean inlink numbers are not statistically different between both parts of the sample and that the responses are representative for the entire sample.

Table 7: Mean inlinks to the life sciences research teams homepages by response status and country (N = 1,668)

Country	Non responses and unusable responses		Usable responses		Results of the statistical tests		
	Mean inlinks	S.E.	Mean inlinks	S.E.	ANOVA F-value	Levene-Test	Welch-Test
	2.2	0.5	1.6	0.5	0.54	1.20	0.81
DE	11.0	1.2	9.5	1.5	0.35	0.32	0.55
ES	3.3	0.8	1.9	0.6	0.91	2.25	1.98
FR	4.2	1.3	4.4	1.1	0.00	0.02	0.08
HU	3.3	0.9	5.8	1.7	2.0	7.00*	1.71
IT	2.4	0.4	1.5	0.3	1.87	3.79+	3.0+
NO	5.2	0.8	7.8	1.9	2.17	8.86**	1.57
PT	7.9	1.6	11.4	2.5	1.50	2.90+	1.39
SE	8.1	1.6	7.3	2.8	0.07	0.00	0.06
UK	7.2	1.0	8.7	2.3	0.47	1.54	0.34
Total	**6.1**	**0.4**	**6.4**	**0.6**	**0.16**	**0.39**	**0.69**
Cases	1,225	-	443	-	-	-	-

F-Test on the congruence of means, Levene-Test on the homogeneity of variances, Welch-Test: robust test on the congruence of means for inhomogeneous variances.

Significance levels: ** p < 0.01, * p < 0.05, + p < 0.1.

Source: NetReAct (FHSO & SCIT).

[4] The Levene-Test points to inhomogeneous variances and we therefore should prefer the Welch-Test as a test for the difference of means. The significance level for the test value is p = 0.084.

Representativeness by total staff, PhD students and post-docs

Calculating mean group sizes for the two parts of the sample with the data retrieved from the groups' web presentations produces a similar result as for the link statistics: neither for the entire ten-country sample nor for individual countries have we found a statistically significant bias in regard to total team size (c.f. table 8). The slight differences in group sizes are in both directions, e.g. the responding teams are slightly larger in Spain and slightly smaller in Italy, but the differences are of a magnitude that is not statistically significant in any of the ten countries.

Table 8: Mean group size (from WWW) by response status and country (N = 1,374)

Country	Non responses and unusable responses		Usable responses		Results of the statistical tests		
	Mean group size	S.E.	Mean group size	S.E.	ANOVA F-value	Levene-Test	Welch-Test
CZ	15.9	1.2	12.8	1.5	1.89	2.02	2.52
DE	16.8	0.8	16.6	1.4	0.01	0.68	0.01
ES	11.4	0.9	14.8	2.2	2.69	4.92*	1.89
FR	18.1	1.2	16.8	1.8	0.30	0.94	0.37
HU	21.5	2.4	22.3	3.0	0.05	0.04	0.05
IT	10.9	1.1	8.8	0.9	1.57	4.68+	2.27
NO	13.2	1.5	11.0	1.6	0.73	0.02	0.96
PT	9.8	1.1	12.6	1.7	2.15	2.43	1.97
SE	13.8	1.2	12.3	1.9	0.44	1.03	0.45
UK	13.1	0.8	13.1	1.4	0.00	0.62	0.00
Total	**14.9**	**0.4**	**14.3**	**0.6**	**0.60**	**0.00**	**0.64**
Cases	995	-	379	-	-	-	-

F-Test on the congruence of means, Levene-Test on the homogeneity of variances, Welch-Test: robust test on the congruence of means for inhomogeneous variances.

Significance levels: ** p < 0.01, * p < 0.05, + p < 0.1.

Source: NetReAct (FHSO).

We calculated the same statistics based on data retrieved from the WWW for PhD students and post-docs (see annex tables A-1 and A-2). The results are not much different to the results shown above. For PhD students there is no significant difference between the teams in the dataset (usable responses) and the other teams. For post-docs there is no difference for the total sample and for eight out of the ten countries. However, Portuguese teams in the dataset have significantly more and Swedish teams significantly less post-docs than their counterparts who did not respond to the survey (or responded, but not with a usable questionnaire). This has to be considered in the analysis of post-docs for both countries.

Representativeness according to gender of the team head

Representativeness of the responses by gender of the team head is also generally given. Approximately 20% of the team leaders are female and they are well represented in the responses (see table 9). For Germany we see a significant overrepresentation and for

Spain an underrepresentation of teams led by females. However, female respondents are included in both countries and the slight variations do not constitute any general problem.

Table 9: Responses by gender of the team head and country of the team (N = 1,771)

Country	Non responses and unusable responses			Usable responses			Chi-Square
	female head	male head	total	female head	male head	total	
CZ	24.7%	75.3%	100.0%	23.3%	76.7%	100.0%	0.023
DE	11.3%	88.7%	100.0%	20.0%	80.0%	100.0%	3.068+
ES	21.3%	78.7%	100.0%	8.1%	91.9%	100.0%	3.316+
FR	16.0%	84.0%	100.0%	12.5%	87.5%	100.0%	0.396
HU	13.5%	86.5%	100.0%	17.6%	82.4%	100.0%	0.315
IT	23.9%	76.1%	100.0%	21.2%	78.8%	100.0%	0.692
NO	23.8%	76.2%	100.0%	18.9%	81.1%	100.0%	0.354
PT	40.5%	59.5%	100.0%	50.0%	50.0%	100.0%	1.034
SE	20.4%	79.6%	100.0%	26.8%	73.2%	100.0%	0.719
UK	13.5%	85.6%	99.1%[a]	13.0%	87.0%	100.0%	0.022
Total	**18.9%**	**80.9%**	**99.8%**[a]	**20.5%**	**79.5%**	**100.0%**	**0.534**
Cases	247	1,056	1,303	96	372	468	-

a Non responses do not add to 100% in the UK, as there were two non responses for which the gender of the team leader could not be identified through the internet.

Significance levels: ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Source: NetReAct (FHSO).

Summary

According to the information available for the sample the responses constitute a representative selection of this sample and – as the sampling was randomised – therefore a representative part of the entire population of life sciences research teams in the 10 NetReAct countries. Minor limitations to representativeness appear:

- For the inlink numbers of Italian teams: As the link figures are presumed to be related to the performance of the teams (see deliverable D1.1, p. 52), we might have a slight underrepresentation of outperforming Italian teams in the sample.
- For the post-docs in Portuguese and Swedish teams, the former having more post-docs per team in the responding teams than in the entire population and the latter having fewer post-docs in the dataset teams.
- In regard to gender in Germany and Spain: In Germany teams led by females are slightly overrepresented and in Spain they are underrepresented among the responding teams.

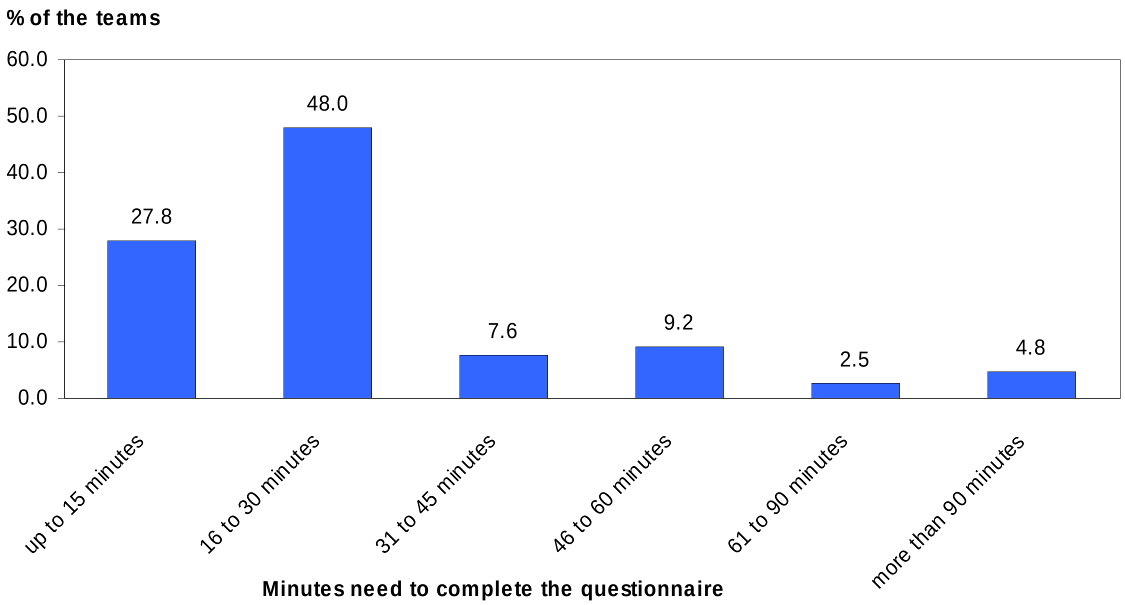
These particularities should be kept in mind in the analysis of the survey results. However, they are all of minor extent and do not affect the validity of the results. No limitations in regard to PhD students could be found.

2.2.4 Time needed to complete the questionnaire

For obtaining a satisfactory response rate it was crucial to keep the effort of responding as low as possible. The NetReAct survey tried to reduce the effort for the team leaders by animating them to delegate some of the responses to assistants. However, only 18 respondents stated that they had delegated questions to assistants or asked colleagues to provide some of the answers for them.

The effort is very well reflected in the time that is needed to complete the questionnaire. The survey software automatically assessed the time at which a link was activated (start of the questionnaire) and when it was closed again. However, this automated time collection is of little use, as respondents tend to do other things in between, access the questionnaire and leave it open for more than a day, or access it several times. Therefore, the questionnaire also included a question that asked for the time needed to complete the questionnaire. The average time needed to fill in the questionnaire was 20 minutes (median) which matches quite well with the projected time of 15 minutes. Three quarters of the respondents needed 30 minutes or less and only 7.3% needed more than an hour (see figure 1). Only few respondents complained about the length of the questionnaire or proposed to make it shorter (15 out of 468 respondents).

Figure 1: Share of respondents by time needed to complete the questionnaire



Source: NetReAct survey.

3 General distribution of the survey responses and role of the PhD students

This chapter provides a general overview of the survey results. In particular, we show the distribution of teams by country, scientific discipline, age and size. These variables are used in the remainder of the deliverable for structuring the responses and comparing different subgroups of teams. A comparison for the numbers of doctoral students and their shares among the total team personnel between different groups of teams is included in the second part of the chapter.

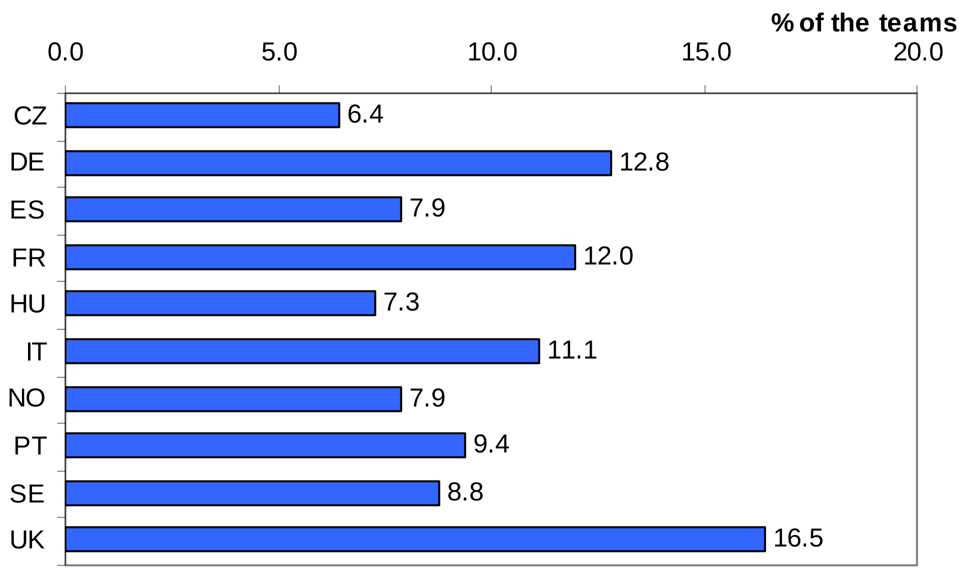
3.1 Distribution of the responses

Distribution by country

The country information is available for all 468 teams which provided usable responses to the survey. Very few team leaders (2 in total) had changed the country between the beginning of 2003 and the realisation of the survey in summer 2005.

As figure 1a shows, the largest share of valid responses comes from the UK (17%). The other big countries in the sample, Germany, France and Italy, also contribute with more than 11% each. Each of the other six, smaller countries make up between 6.5 and 9.5% of the total. Even for the country with the smallest number of usable responses, the Czech Republic, we reach the threshold of 30 responses (see table A-3 in the annex).

Figure 1a: Share of teams by country



Source: NetReAct survey.

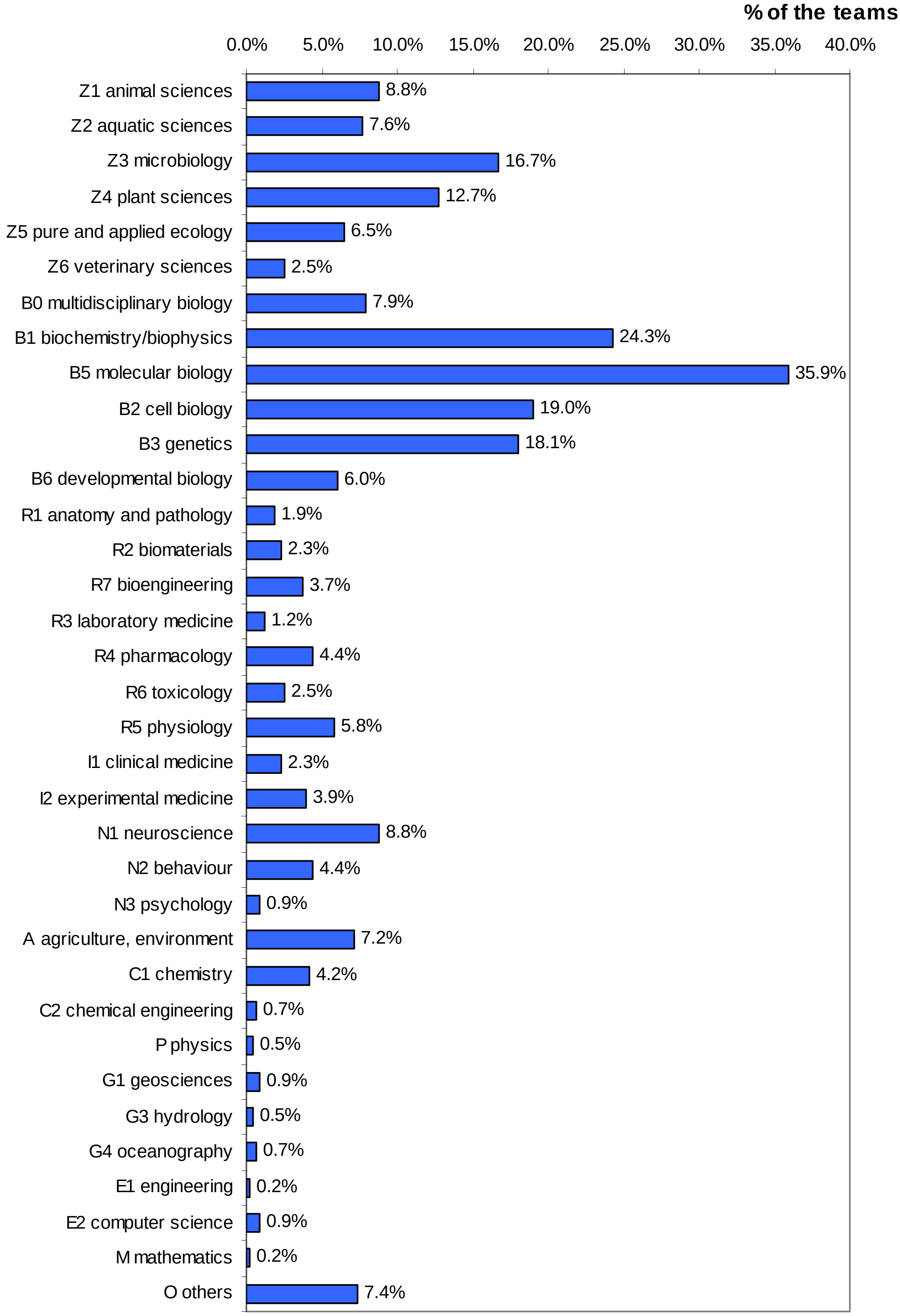
Distribution by field and discipline

In order to assess the academic disciplines of the research groups the questionnaire included a question on the most important fields covered by PhD research at the beginning of 2003. According to the exploratory interviews conducted in advance to the survey, it was decided to use the research-oriented K.U. Leuven – IRO Subject Classification, as some interviewees (team leaders in the life sciences) had problems to match their research activities with the rather education-oriented ISCED 1997 classification (see D1.1, p. 60). Annex table A-4 shows the classification that was included in the questionnaire as drop-down lists. The respondents were asked to select a maximum of three fields from this list.

Out of 468 usable responses 36 (7.7%) had missing values for this question. This might be due to the focus on "PhD research": If the respondents did not have any PhD students in their team, they might not have known how to answer the question.

The distribution of the valid responses by field is shown in figure 2. The largest share of 36% of the teams carried out PhD research in molecular biology; next comes biochemistry/biophysics in which nearly one fourth of the teams were active. Further big fields present in 15-20% of the teams are cell biology, genetics, and microbiology.

Figure 2: Share of teams by discipline



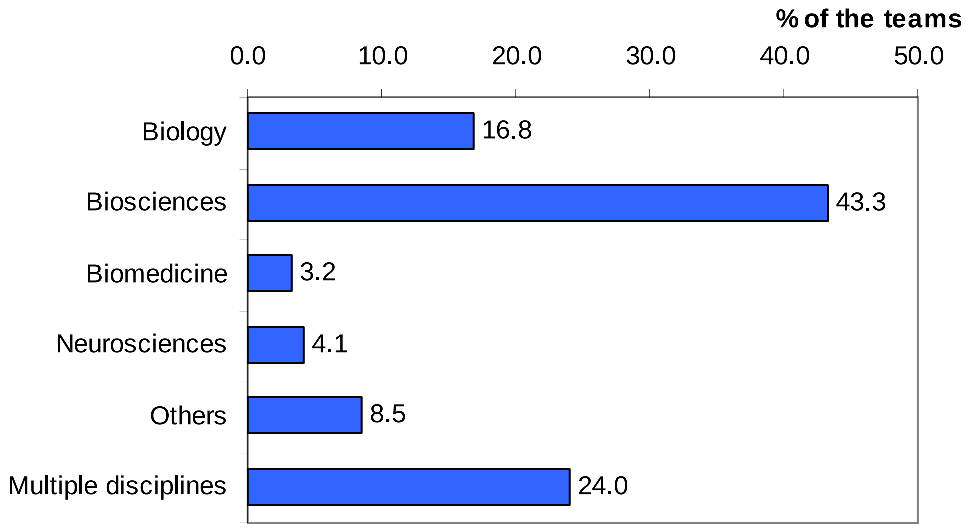
a Percentages exceed 100% as up to three answers were possible.

Source: NetReAct survey.

As a next analytical step the fields were added to academic disciplines. We proceeded as follows: all fields were added to the disciplines biology (Z-fields), biosciences (B-fields), biomedicine (R-fields), neurosciences (N-fields), and other disciplines (I-, A-, C-, P-, G-, E-, M-, and O-fields). The main discipline was selected as the one to which the majority of fields could be attributed, e.g. if the respondent gave three fields B5 molecular biology, B2 cell biology, and Z3 microbiology the main discipline B biosciences was selected. If two or three fields in different disciplines were chosen by the respondent and a clear majority could not be found the case was labelled as multidisciplinary.

Figure 3 shows the results according to the IRO - K.U. Leuven Subject Classification. Again, the figure shows that biosciences are the most important discipline in the dataset. More than 40% of the teams belong primarily to this discipline. Nearly one fourth of the teams were classified as multidisciplinary and 17% facilitate PhD research in biology. Biomedicine, neurosciences and other disciplines are less important.

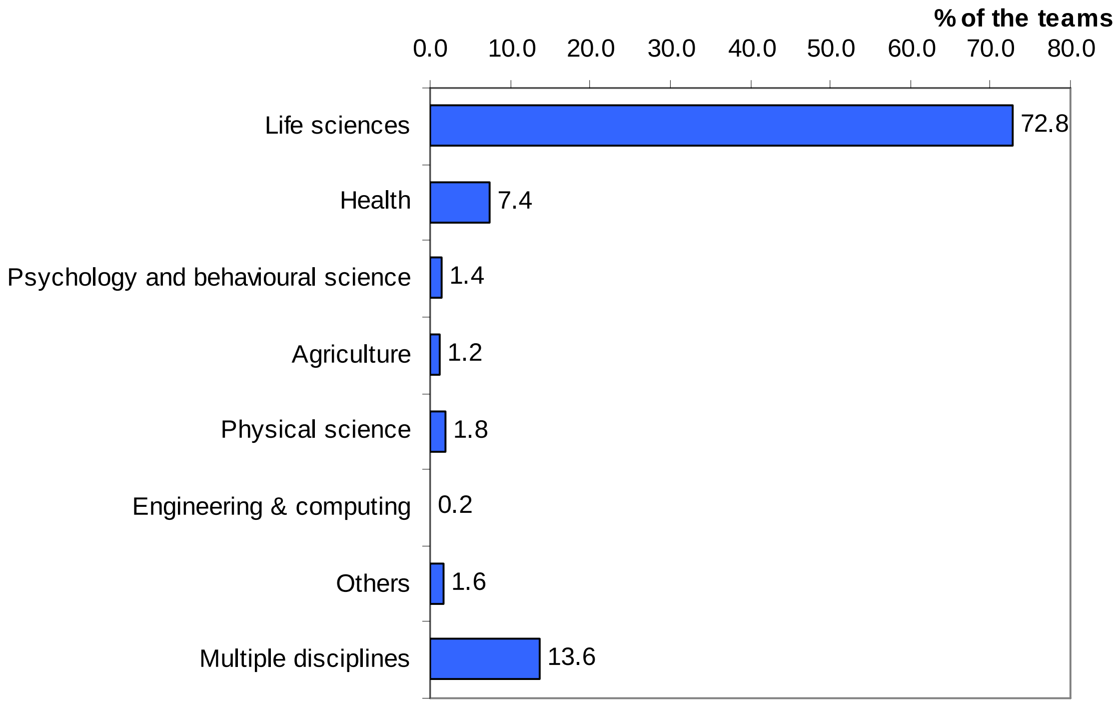
Figure 3: Share of teams by main scientific discipline (K.U. Leuven – IRO Subject Classification)



Source: NetReAct survey.

The ISCED 1997 classification constitutes a different alternative of structuring the research teams by discipline. However, as ISCED 1997 was used for selecting the teams and constructing the dataset in the first place, we should not expect many teams with PhD research outside of the main focus of the analysis, the ISCED category 42 “Life sciences”. Indeed, as figure 4 shows, the large majority of research teams for which the disciplinary information is available mainly facilitate PhD research in this discipline. And even among the teams which do primarily work in other fields or which were classified as multidisplinary another 67 also do research in the life sciences raising the total share of teams active in life sciences fields to 88%.

Figure 4: Share of teams by main scientific discipline (ISCED 1997 Classification)



Source: NetReAct survey.

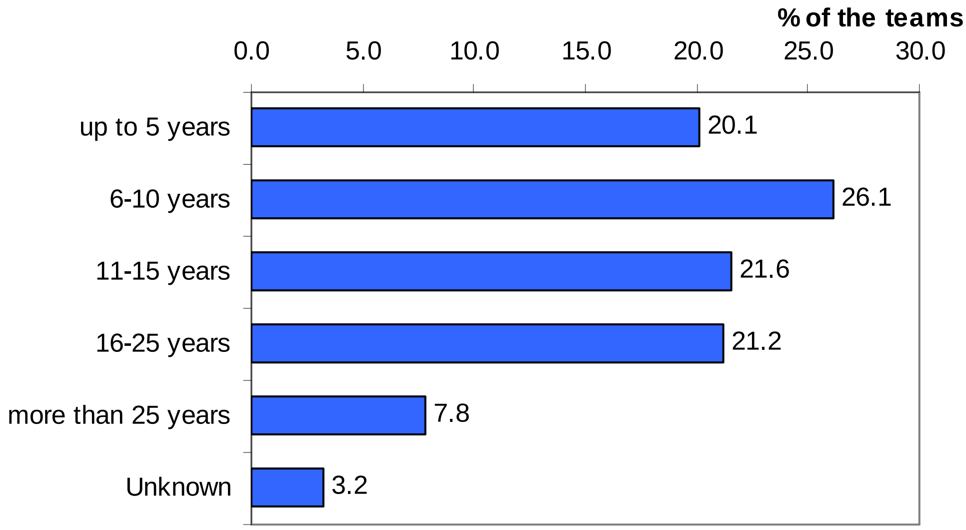
As, in line with the general aim of the analysis, the large majority of research teams have a research focus in the life sciences, the ISCED 1997 classification is not useful for a further differentiation of the dataset. The analysis of the disciplinary information will be based on the K.U.L.-IRO classification.

Distribution by age of the team

In order to assess the age of the teams, a question was included in the questionnaire that asked for the year in which the group had started to do research. This specification was preferred to the year of founding or official recognition of a team which may differ from the year in which the research started, as the exploratory interviews had shown (see D1.1, pp. 59-60).

Figure 5 provides the grouped responses to this question converted to the age of the team. Accordingly, nearly half of the teams are up to 10 years old and almost 90% are not more than 25 years old. Only a small percentage of 8% is more than 25 years old. For few teams the actual starting year of research was not known by the respondent – we can assume that these are older teams, too, which were founded before the current leader had taken over.

Figure 5: Share of teams by age of the team



Source: NetReAct survey.

Distribution by team size

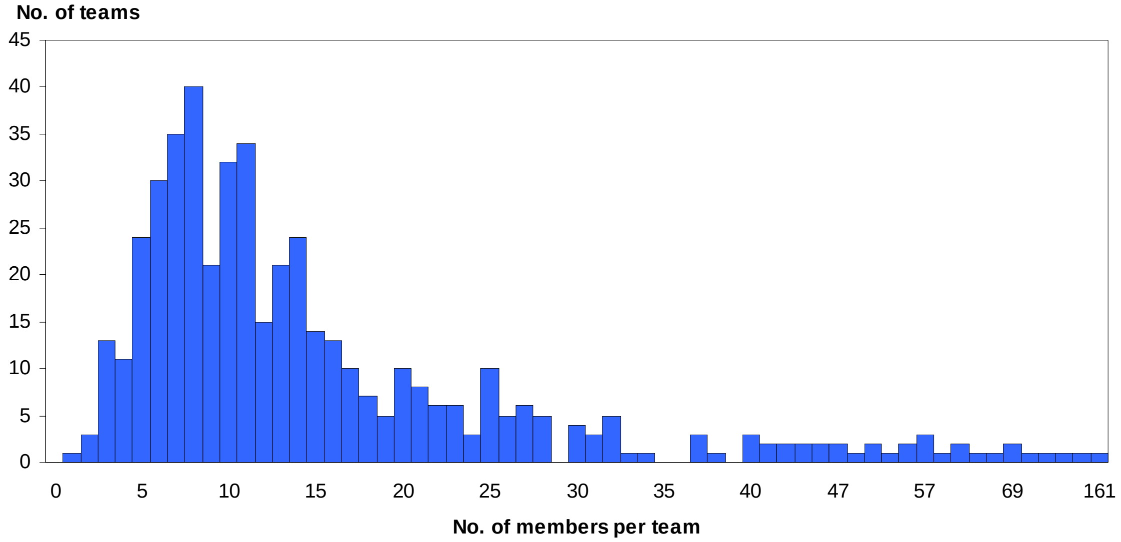
Seven different personnel categories were assessed for each team:

- Principal investigators (e.g. team leaders, professors)
- Post-doctoral researchers (usually PhD under 5 years ago i.e. 1998 or after)
- Other researchers (with PhD before 1998)
- PhD students
- Other research students (e.g. Masters students)
- Technical Staff (posts not requiring PhD or equivalent)
- Other staff (e.g. administrative)

The respondents were asked to include in this numbering all personnel on leave for less than 6 months and guests or visitors staying for more than 6 months. The responses were summed up to obtain the total size of each team. The range of team size is from 1 (1 case) to 161 members (c.f. figure 6) and the histogramm shows a peak in the range of 7-11 members (sizes with 0 cases are not shown for team sizes larger than 40). The 3 cases with more than a hundred team members (161, 137, and 132) should probably be considered as outliers. But even among the other 16 teams with more than fifty members a majority are probably not teams according to our definition (see chapter 1.2) but entire institutes or departments.

Average team size is 11.0 members (median). The median is the better mean value in this case because of the outliers. The arithmetic mean of 16.2 team members is slightly larger than the team size as obtained from the WWW (14.3 persons, see table 8, p. 25). However, the data from the WWW has two weaknesses compared to the survey data: it includes all people listed on the website, except for research students at master level, provided that they were labelled as such and could be excluded. They were excluded from the web staff data, because we had not been able to identify a common practice of counting them as team members or not. Moreover, for the larger units in the survey no figures on team members were available on the web.

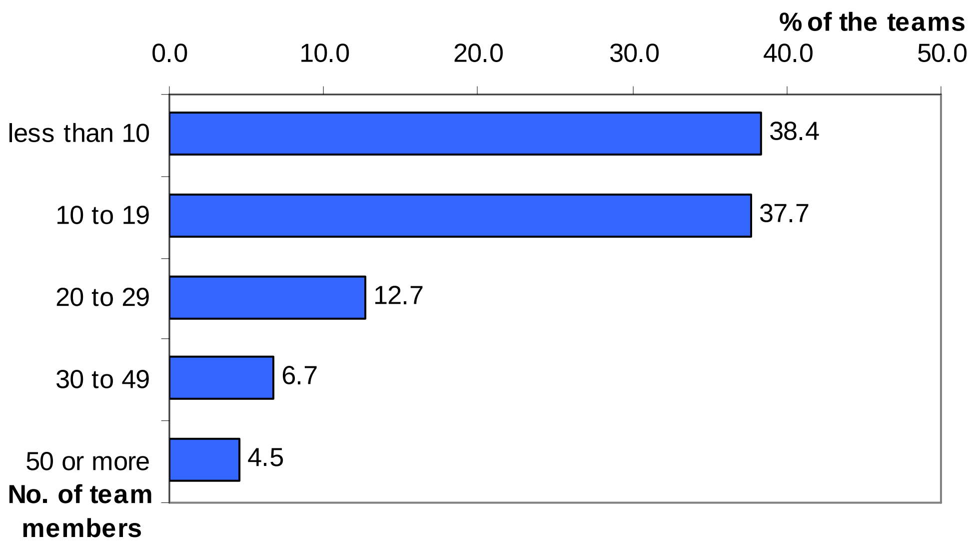
Figure 6: Histogramm of team sizes[a]



a Sizes with 0 cases are not shown for team sizes larger than 40.

Source: NetReAct survey.

Figure 7: Share of teams by team size group



Source: NetReAct survey.

Nearly 40% of the teams are small teams with less than 10 members and another 40% of the teams are medium-sized with 10 to 19 members (c.f. figure 7). Only 12.7% of the teams have 20 to 29 members. We assume that among the very big teams with 30 to 50 or even 50 and more members a number of departments or institutes are included – however, they add up to roughly 11% of the total only and therefore they will play a negligible role in the overall analysis.

3.2 Doctoral students by teams

3.2.1 Basic team structures

A more detailed analysis of the team structure will be presented in subsequent deliverables of the NetReAct project. The present section only aims at giving a very brief overview of the team structure by personnel category in order to put the analysis of doctoral students into context.

From a quantitative perspective doctoral students are by far the most important personnel group of the research teams in the dataset (c.f. table 10): on average 4.6 doctoral students work in the teams. This is more than 25% of the team members and in line with the results of previous work: For instance, in French life sciences labs, PhD students are estimated to account for nearly 30% of qualified manpower (Mangematin & Robin, 2003). Laredo (1999, 2001) obtains a similar share for labs in human genetics in six different European countries. If technicians are included and the overall lab size is calculated, still one fourth of the human genetics personnel are PhD students. A similar percentage can be calculated from the data on the labs at the University of Louis Pasteur Strasbourg provided by Carayol and Matt (2004): 32% of their scientists are PhD students.

Furthermore, between two and three principal investigators, post-docs, other research students and technical staff worked on average in a team. Other researchers and other staff were less important. Looked at it from a different perspective, around two third of the team members were scientists and one third were assistants (other research students, technicians, administrative and other staff).

Table 10: Personnel structure of the life sciences teams responding in the survey

	Arithmetic mean	Standard error of the mean	In % of total team size
Principal investigators	2.4	0.12	14.7
Post-doctoral researchers	2.2	0.12	13.8
Other researchers	1.4	0.15	8.9
PhD students	4.6	0.20	28.2
Other research students	2.7	0.19	16.6
Technical staff	2.1	0.17	12.8
Other staff	0.9	0.26	5.3
Total group size	**16.2**	**0.77**	**100.0**

Source: NetReAct survey.

3.2.2 Role of doctoral students in different groups of life sciences teams

The present chapter further looks at the total number of doctoral students and investigates, whether their role differs between different groups of teams. The analysis distinguishes between the countries, academic disciplines, ages and sizes of the teams.

Doctoral students by country of the team

If the number and percentages of doctoral students are differentiated by the country of the team (c.f. table 11), four groups of countries appear:

- Italian and Hungarian teams had relatively few PhD students, only 3.3 (3.6) per team, and they were of rather little importance compared to other personnel groups, i.e. they constituted only little more than one fifth of the total team personnel.
- Czech and French teams had many doctoral students, but the teams were relatively big and therefore the importance of PhD students was low, as in Italy and Hungary.
- Life sciences teams in Germany and Portugal, and the UK had more doctoral students than on average and the students were also more important than in the previously described countries taking the ratio of PhD students to total personnel.
- For the Spanish, Swedish and Norwegian teams we counted rather few PhD students. However, they are close to the ten country average and there is a notable proximity between the median and mean values for Spain and Sweden which means that there are few outliers which would raise the arithmetic mean. For all three countries, the share of PhD students among the total staff is also above the average. Hence, this group can be considered to be rather close to the previously discussed group of German, Portuguese and British teams.

Table 11: Doctoral students by country of the team

Country	Median	Arithmetic mean	95 % Confidence interval of the mean		In % of total staff	No. of teams
			lower bound	upper bound		
CZ	3.5	6.0	3.7	8.3	26.1	30
DE	4.0	5.3	4.3	6.4	33.1	60
ES	4.0	4.0	2.9	5.0	31.1	37
FR	3.0	4.6	3.4	5.8	20.6	55
HU	3.0	3.6	2.6	4.6	22.9	33
IT	2.0	3.3	2.3	4.3	21.6	51
NO	3.0	3.8	2.5	5.1	31.0	37
PT	5.0	5.7	4.4	6.9	33.6	43
SE	4.0	4.3	3.4	5.2	41.5	41
UK	3.0	4.9	3.5	6.2	29.6	77
Total	**3.0**	**4.6**	**4.2**	**5.0**	**28.2**	**464**

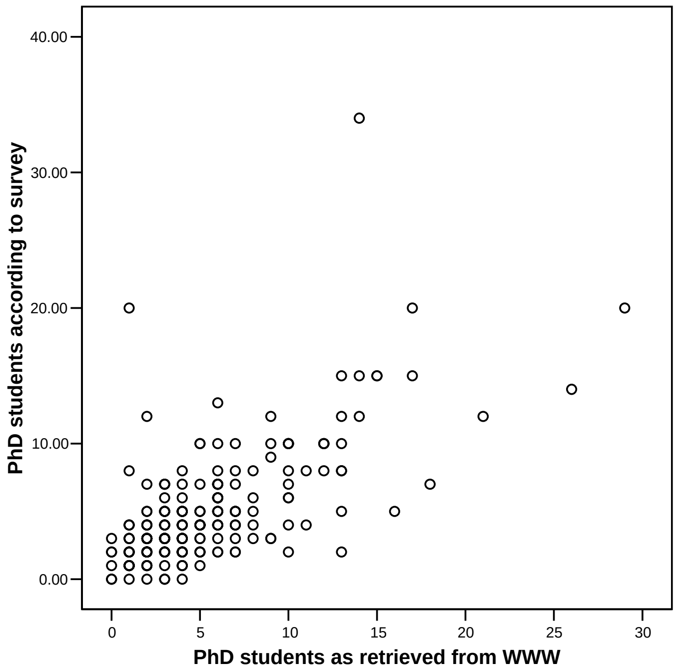
F-Test on the congruence of means: F-value 1.799, $p<0.1$
Levene-Test on the homogeneity of variances: 2.748, $p<0.01$
Robust tests on the congruence of means: Welch-Test: 2.045, $p<0.05$, Brown-Forsythe-Test: 1.908, $p<0.1$

Source: NetReAct survey.

The results do not render themselves to an easy explanation. New and old EU member states, northern and southern countries and eastern and western countries show similarities. All in all, the variation across countries was rather small, which is also confirmed by the low significance of the test statistics reproduced below the table.

The validity of the survey data on doctoral students can be checked by comparing it with the data retrieved from the WWW. Just a general comparison is possible, as only for every second team data could be found on the web, survey and web data are not necessarily for the same point in time, and in some cases graduate students and PhD students could not be separated without doubt according to what was written on the groups' web pages. However, the similarity is strikingly high (see table 11 in comparison to table A-1 in the annex, p. 91): according to the web the teams had 5.0 PhD students and according to the survey 4.6. Even for the individual countries the figures obtained from the web resemble very much the survey results. The Pearson correlation coefficient between both data series is 0.68 and highly significant. The scatter plot shows this relationship (see figure 8). This finding reinforces the validity of both sources of information on doctoral students in the life sciences.

Figure 8: Number of doctoral students according to the survey responses and teams' web presentations (N=259, dots overlaying)



Source: NetReAct survey and data collection from the WWW (FHSO).

Doctoral students by main academic discipline of the team

There is no clear picture of disciplinary differences in regard to the importance of doctoral students (see table 12). Medians and arithmetic means for individual disciplines are rather close to the total sample values, the confidence intervals of the means are rather big, and the ratios of PhD students to total staff vary between one fourth and one third. The statistical tests neither permit to speak of significant differences. Only for biomedical research teams we get an average of 5.4 PhD students which equals roughly one third of the total team personnel. However, the standard error for the arithmetic mean of PhD students in biomedicine is rather large, too, and therefore this result should be interpreted with caution.

Table 12: Doctoral students by main academic discipline of the team

Main discipline	Median	Arithmetic mean	95 % Confidence interval of the mean		In % of total staff	No. of teams
			lower bound	upper bound		
Biology	3.0	5.0	3.8	6.2	28.1	71
Biosciences	3.0	4.3	3.6	4.9	29.0	187
Biomedicine	3.0	5.4	1.6	9.1	33.8	14
Neurosciences	3.5	4.7	3.0	6.4	27.7	18
Others	3.0	4.0	2.8	5.2	25.1	37
Multiple disciplines	4.0	5.4	4.6	6.2	28.3	104
Total	**3.0**	**4.7**	**4.3**	**5.1**	**28.4**	**431**

F-Test on the congruence of means: F-value 1.121, insignificant at p<0.1
Levene-Test on the homogeneity of variances: 1.302, insignificant at p<0.1
Robust tests on the congruence of means: Welch-Test: 1.198, insignificant at p<0.1, Brown-Forsythe-Test: 1.003, insignificant at p<0.1

Source: NetReAct survey.

Doctoral students by age of the team

The team age exerts some influence on the number of doctoral students. However, a clear difference to the rest is only obtained for the youngest teams which started research less than five years ago in the period 2000-2003 (c.f. table 13). They clearly had fewer doctoral students than older teams, and the doctoral students also constituted a smaller part of the teams. This might be due to the fact that these young teams were still in the process of being established and that in the beginning of 2003, i.e. not more than 3 years after they had started to do research, some of the positions for doctoral students still had to be filled. For the other groups of older teams a clear-cut trend cannot be seen.

Table 13: Doctoral students by age of the team

Age of the team	Median	Arithmetic mean	95 % Confidence interval of the mean		In % of total staff	No. of teams
			lower bound	upper bound		
up to 5 years	2.0	2.8	2.3	3.4	24.1	92
6-10 years	4.0	5.1	4.1	6.1	29.9	120
11-15 years	4.0	4.9	4.1	5.7	28.2	99
16-25 years	3.0	4.8	3.9	5.7	32.1	98
more than 25 years	4.0	4.9	3.3	6.6	21.9	36
Unknown	4.0	4.9	3.4	6.4	28.2	15
Total	**3.0**	**4.5**	**4.1**	**4.9**	**28.2**	**460**

F-Test on the congruence of means: F-value 3.644, p<0.01
Levene-Test on the homogeneity of variances: 3.501, p<0.01
Robust tests on the congruence of means: Welch-Test: 6.763, p<0.01, Brown-Forsythe-Test: 4.051, p<0.01

Source: NetReAct survey.

Doctoral students by size of the team

It is somewhat trivial to state that smaller teams had fewer PhD students than larger teams. The important column in table 14 is the one that shows the ratio of PhD students to total staff of the teams. Above all it shows that large units with 50 or more members had a smaller percentage of doctoral students than teams with fewer personnel. However, this might be caused by the fact that these large teams are not always research teams according to our definition, but departments or institutes which also employ a larger share of overhead staff.

Table 14: Doctoral students by total size of the team

Total team members	Median	Arithmetic mean	95% Confidence interval of the mean		In % of total staff	No. of teams
			lower bound	upper bound		
less than 10	2.0	2.0	1.9	2.2	31.8	178
10 to 19	4.0	3.8	3.6	4.1	29.1	175
20 to 29	7.0	7.4	6.5	8.2	31.3	59
30 to 49	11.0	10.8	8.9	12.7	29.0	31
50 or more	15.0	15.2	11.6	18.9	20.8	21
Total	**3.0**	**4.6**	**4.2**	**5.0**	**28.2**	**464**

F-Test on the congruence of means: F-value 172.303, p<0.01
Levene-Test on the homogeneity of variances: 72.805, p<0.01
Robust tests on the congruence of means: Welch-Test: 87.509, p<0.01, Brown-Forsythe-Test: 46.402, p<0.01

Source: NetReAct survey.

Summary

Doctoral students were the biggest staff group in life sciences research teams. Nearly 3 out of 10 team members were doctoral students and the teams in the sample employed on average 4.6 PhD students.

The numbers of doctoral students per team vary across the countries in the sample, but there are no clear divides – like North-South, old-new member state, big-small country etc. – to be seen. The comparison of data on PhD students from two different sources (the WWW and the survey) shows striking similarities between both data series even though there are major structural differences between them. This proves the general validity of both methods for obtaining information on the number of PhD students in research teams, at country level but also at the level of the individual research team.

A comparison of the number of doctoral students between teams having their major research focus in different life sciences disciplines did not produce any meaningful results. Taking the age of the team, we find that teams younger than 5 years tended to have fewer students than older teams. In addition, large teams with 50 or more team members had fewer PhD students than smaller teams. However, this might be due to a misunderstanding on the side of the respondents who provided information for entire departments or institutes and not teams, as requested. Departments usually employ overhead staff (e.g. administration, library, joint laboratories etc.) which would inflate the denominator in the ratio of PhD students to total team members.

The following chapter provides a more detailed analysis of the doctoral students in the life sciences research teams.

4 Characterisation of the doctoral students in life sciences teams

The present section is based on questions asked in table format in which the survey respondents, the heads of the life sciences research teams, were asked to provide information on a selection of PhD students. The questions asked for a maximum of five PhD students who most recently (but before 2003) had joined the team or who most recently had left the team with or without terminating their PhD work. The threshold of five students was deemed necessary to keep the effort of responding to the survey as low as possible. However, as we saw above the average number of PhD students per team is 4.6 (c.f. table 10, p. 35). More than 75% of all teams had 5 or fewer doctoral students and only 8% had more than 10. Therefore, the information obtained covers all students in a large part of the dataset and is still meaningful for the majority of the rest.

For most variables we obtained information on more than 1,500 PhD students working in the teams in 2003 (the country distribution covers even 1,600 to 1,700 students) and 1,400 students who left the teams since 2003.

4.1 Doctoral students working in the teams in 2003

This section differentiates the age, gender, discipline of doctoral research, country of origin and last degree, and source and duration of funding of the PhD students by the country, main discipline, age and size of their team.

4.1.1 Age

The mean age of the PhD students across the entire sample was 27.4 years. It varies to some extent between the included countries: the doctoral students in Norwegian and Swedish teams were on average 2-3 years older than in the entire dataset. British doctoral students, on the other hand, were on average 2 years younger. For the other seven countries in the dataset the average age of the PhD students was within the range of the overall mean of 27.4 ± 1 year.

Table 15: Mean age of doctoral students by country of the team

Country of the team	Arithmetic mean	95% Confidence interval of the mean lower bound	upper bound	Valid cases
CZ	26.4	25.1	27.7	24
DE	27.7	27.0	28.4	46
ES	27.0	25.6	28.4	33
FR	26.2	25.4	27.0	48
HU	27.2	25.6	28.7	30
IT	28.4	27.1	29.7	44
NO	30.4	28.2	32.7	32
PT	27.1	26.1	28.2	36
SE	29.6	28.1	31.1	35
UK	25.4	24.5	26.3	65
Total	**27.4**	**27.0**	**27.8**	**393**

F-Test on the congruence of means: F-value 6.609, $p<0.01$
Levene-Test on the homogeneity of variances: 3.521, $p<0.01$
Robust tests on the congruence of means: Welch-Test: 5.144, $p<0.01$, Brown-Forsythe-Test: 6.302, $p<0.01$

Source: NetReAct survey.

Differentiating the age by the main discipline (according to IRO-K.U.L.) returns a higher average age for PhD students in biomedical research teams and a lower average age for teams in neurosciences (table 16).

Table 16: Mean age of doctoral students by main academic discipline of the team

Main discipline of the team	Arithmetic mean	95% Confidence interval of the mean lower bound	upper bound	Valid cases
Biology	28.2	27.1	29.4	65
Biosciences	26.8	26.2	27.5	156
Biomedicine	29.9	27.2	32.6	13
Neurosciences	25.4	24.1	26.8	16
Others	28.3	26.6	30.0	28
Multiple disciplines	27.4	26.6	28.2	87
Total	**27.4**	**27.0**	**27.8**	**365**

F-Test on the congruence of means: F-value 3.087, $p<0.05$
Levene-Test on the homogeneity of variances: 1.135, insignificant at $p<0.1$
Robust tests on the congruence of means: Welch-Test: 3.707, $p<0.01$, Brown-Forsythe-Test: 3.241, $p<0.01$

Source: NetReAct survey.

The tables for the mean age of doctoral students differentiated by the team age and size do not include any clear patterns or significant differences and therefore they are not reproduced in this report.

4.1.2 Gender

Interestingly, there were slightly more female than male PhD students in the analysed life sciences research teams (c.f. table 17). This finding applies to the majority of countries in the dataset. It is particularly pronounced for Portuguese and Italian research teams, in which more than six out of ten doctoral students were female. German and Swedish life sciences research teams had nearly equal numbers of male and female doctorants and only in British teams there was a slight dominance of the males.

Table 17: Percentages of doctoral students by gender and country of the team

Country of the team	Gender of the doctoral student					
	Male PhD students		Female PhD students		All PhD students	
	N	In %	N	In %	N	In %
CZ	41	45.1%	50	54.9%	91	100.0%
DE	112	50.5%	110	49.5%	222	100.0%
ES	48	44.9%	59	55.1%	107	100.0%
FR	93	47.9%	101	52.1%	194	100.0%
HU	47	45.6%	56	54.4%	103	100.0%
IT	62	39.0%	97	61.0%	159	100.0%
NO	53	47.3%	59	52.7%	112	100.0%
PT	48	38.4%	77	61.6%	125	100.0%
SE	82	50.6%	80	49.4%	162	100.0%
UK	147	52.9%	131	47.1%	278	100.0%
Total	**733**	**47.2%**	**820**	**52.8%**	**1,553**	**100.0%**

Source: NetReAct survey.

The gender distribution of PhD students also varies between the academic disciplines (c.f. table 18): in neurosciences research teams there was a clear female dominance, whereas male PhD students were the majority in biomedical research teams and in teams which predominantly carried out PhD research in other fields in the natural sciences.

Table 18: Percentages of doctoral students by gender and main discipline (IRO-K.U.L.)

Main discipline of the team	Gender of the doctoral student					
	Male PhD students		Female PhD students		All PhD students	
	N	In %	N	In %	N	In %
Biology	121	48.0%	131	52.0%	252	100.0%
Biosciences	311	47.0%	351	53.0%	662	100.0%
Biomedicine	27	56.3%	21	43.8%	48	100.0%
Neurosciences	16	31.4%	35	68.6%	51	100.0%
Others	68	54.0%	58	46.0%	126	100.0%
Multiple disciplines	174	46.5%	200	53.5%	374	100.0%
Total	**717**	**47.4%**	**796**	**52.6%**	**1,513**	**100.0%**

Source: NetReAct survey.

There does not seem to be any relationship between the team age and the distribution of PhD students by gender (c.f. table A-5). Smaller teams more often employed male doctoral students whereas larger teams more often employed female doctoral students (c.f. table 19) – keeping in mind that the largest "teams" with 50 or more team members are probably in many cases not teams according to our definition but departments or institutes. However, it should also be noted that the question referred to a maximum of five PhD students per team. The larger the teams get, the smaller the share of doctoral students actually working in the team that is covered by this question.

Table 19: Percentages of male and female doctoral students by team size

Total team members	Gender of the doctoral student					
	Male PhD students		Female PhD students		All PhD students	
	N	In %	N	In %	N	In %
less than 10	255	52.1%	234	47.9%	489	100.0%
10 to 19	297	46.0%	348	54.0%	645	100.0%
20 to 29	81	39.7%	123	60.3%	204	100.0%
30 to 49	51	42.1%	70	57.9%	121	100.0%
50 or more	44	52.4%	40	47.6%	84	100.0%
Total	**728**	**47.2%**	**815**	**52.8%**	**1,543**	**100.0%**

Source: NetReAct survey.

4.1.3 Main discipline of doctoral research

The overall distribution of the PhD students by their main discipline of doctoral research is shown in table 20. Some notable variations between countries are:

- Biology PhD students were overrepresented in Germany and Norway and they are of low significance in Hungary and Italy.
- Students in the biosciences were overrepresented in Italy, the Czech Republic, and Sweden and underrepresented in Portugal and Norway.
- Portuguese and British teams educated many biomedical PhD students, whereas German, Italian and Swedish teams had only relatively few PhD students in biomedicine.
- PhD students in the neurosciences were very important in French, German and Hungarian teams, and (almost) inexistent in Czech and Swedish teams.

Table 20: Percentages of doctoral students by their discipline of doctoral research and country of the team

Country of the team	Discipline of the doctoral student					All PhD students
	Biology	Bio-sciences	Bio-medicine	Neuro-sciences	Other disciplines	
CZ	27.5%	58.2%	8.8%	1.1%	4.4%	91
DE	34.7%	43.4%	3.2%	8.2%	10.5%	219
ES	26.2%	43.0%	5.6%	5.6%	19.6%	107
FR	23.2%	42.8%	6.7%	11.9%	15.5%	194
HU	10.1%	43.1%	9.2%	11.0%	26.6%	109
IT	15.6%	60.0%	4.4%	5.6%	14.4%	160
NO	49.1%	29.5%	7.1%	5.4%	8.9%	112
PT	30.7%	36.2%	12.6%	4.7%	15.7%	127
SE	26.1%	53.9%	3.6%	0.0%	16.4%	165
UK	24.0%	47.3%	10.4%	4.7%	13.6%	279
Total	**26.5%**	**46.1%**	**7.0%**	**6.0%**	**14.4%**	**1,563**

Source: NetReAct survey.

Comparing the disciplines of the up to five doctoral students for which individual information was listed with the main discipline of the team (which was also defined on the basis of the most important fields of PhD research in the group in 2003) we see, as we should expect, that the largest values are generally to be found on the diagonal. For instance, nearly 80% of the PhD students who obtain a PhD in a biology team do this in a biology field. We find this overrepresentation in all disciplines. Biomedical teams, however, are not too much focussed on purely biomedical graduate degrees: nearly half of their PhD students study for a degree in another discipline, many times even in other sciences outside of the life sciences. In other words, biomedical teams seem to be more multidisciplinary than the other teams.

Table 21: Percentages of doctoral students by their discipline of doctoral research and the main discipline of the team

Main discipline of the team	Discipline of the doctoral student					All PhD students
	Biology	Bio-sciences	Bio-medicine	Neuro-sciences	Other disciplines	
Biology	80.1%	8.0%	2.4%	0.8%	8.8%	251
Biosciences	8.7%	81.3%	2.4%	2.1%	5.4%	664
Biomedicine	12.5%	6.3%	52.1%	2.1%	27.1%	48
Neurosciences	5.4%	1.8%	7.1%	82.1%	3.6%	56
Others	20.6%	14.3%	2.4%	0.0%	62.7%	126
Multiple disciplines	30.7%	31.2%	13.3%	6.7%	18.1%	375
Total	**26.9%**	**46.0%**	**6.8%**	**5.8%**	**14.5%**	**1,520**

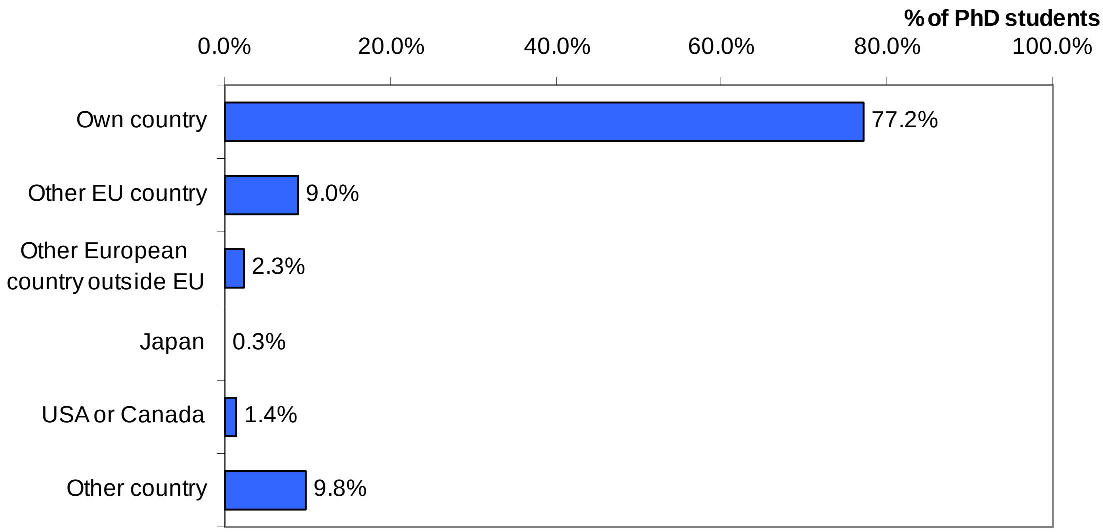
Source: NetReAct survey.

There are only small differences in regard to the discipline of the PhD work and team age and size (see annex tables A-6 and A-7): PhD students in biomedicine and neurosciences are underrepresented in young and very small teams and often work in teams which are of medium age (11-25 years) and size (10-50 team members).

4.1.4 Countries of origin and last degree

The PhD students for which information is available in the dataset came from 87 different countries. More than three out of four PhD students for which the team leaders provided this information came from the same country in which they studied for the PhD (see figure 9). Roughly 10% came from another EU member state or from another country worldwide outside of Europe, North America or Japan. Other European countries outside of the EU (including Romania, Turkey, Russia and the other states formerly part of the Soviet Union) contributed a rather small percentage of 2.3% of the PhD students. From the US or Canada came 1.4% and from Japan just 0.3% (5 PhD students). A separate analysis of the distribution of Japanese students was therefore not justified and they were added to the "other country" category. This group includes a large number of countries worldwide, with China (22 students, 1.3%), India (16 students, 0.9%), Brazil (12 students, 0.7%), Argentina and Iran (11 and 10 students, 0.6%) as the most important countries of origin. However, lots of other countries from Africa, Asia, or South America are also represented in the dataset.

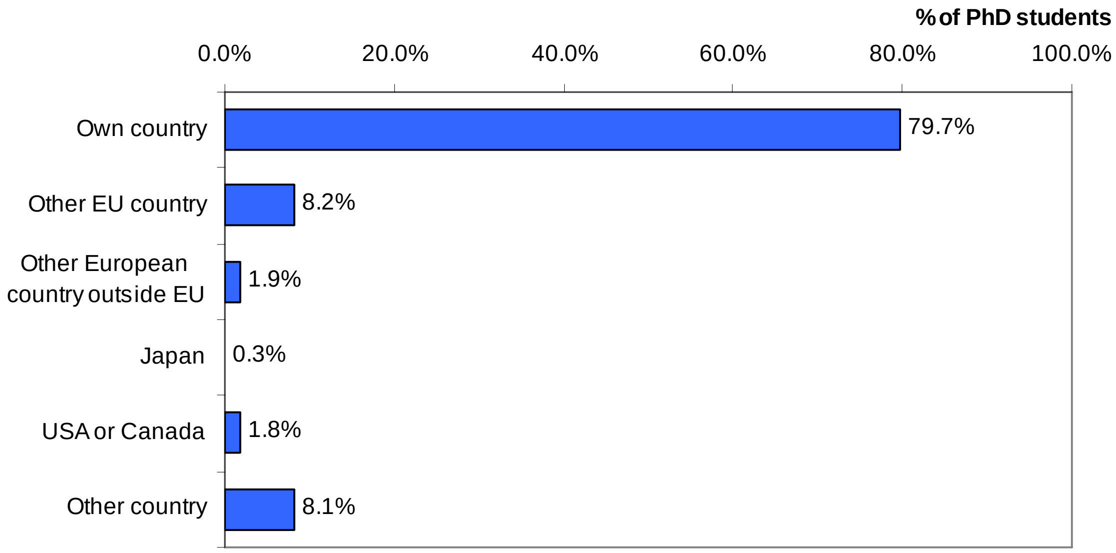
Figure 9: Percentages of doctoral students by their country of origin



Source: NetReAct survey.

If we take the country of last degree – usually the masters degree or diploma – instead of the country of origin we get a very similar picture (see figure 10). Even more students (80%) graduated in the same country in which they wrote the PhD and fewer of them graduated elsewhere – except for the USA and Canada. Some students obviously had gone to study in the US and they came back for getting their PhD in Europe.

Figure 10: Percentages of doctoral students by their country of last degree



Source: NetReAct survey.

Table 22: Percentages of doctoral students by their country of origin and the country of the team

Country of the team	Country of origin of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
CZ	91.6%	6.5%	0.0%	0.0%	1.9%	107
DE	70.5%	9.4%	5.6%	1.3%	13.2%	234
ES	82.2%	2.0%	0.0%	0.7%	15.1%	152
FR	82.5%	5.2%	1.5%	1.0%	9.8%	194
HU	88.3%	1.8%	6.3%	0.0%	3.6%	111
IT	89.8%	5.6%	2.3%	0.0%	2.3%	177
NO	78.9%	12.2%	1.6%	2.4%	4.9%	123
PT	92.4%	2.1%	0.7%	0.0%	4.9%	144
SE	63.0%	17.0%	2.4%	1.2%	16.4%	165
UK	59.5%	17.7%	1.7%	4.3%	16.7%	299
Total	**77.2%**	**9.0%**	**2.3%**	**1.4%**	**10.1%**	**1,706**

Source: NetReAct survey.

In seven out of the ten countries more than three out of four PhD students were born in the country of the team (table 22). Only in three countries there were more than 25% of the students from abroad: the UK, Sweden, and Germany. Great Britain has the highest shares of PhD students from other EU countries, North America and other countries worldwide. This makes UK teams the most international teams in the sample. In Sweden students from other EU countries and other countries worldwide were particularly well represented and in Germany there were lots of doctoral students from other European countries outside the EU. The results for the country of last degree are similar and need not be discussed separately (see table A-8 in the annex).

Simple diversity indices can be calculated with the information on the whole range of countries of origin of the PhD students. The Shannon Diversity Index uses this information and shows the diversity of countries in a team by means of the following formula:

$$D_S = \sum_{i=1}^{C} (p_i * \ln p_i)$$

with D_s Shannon's Diversity Index
C Total number of different countries *i* of origin in a team (max. 5)
p_i Proportion of C made up of the *i*th country

The results corroborate the results obtained from the analysis of country groups (c.f. table 23). The largest diversities of 0.6-0.7 are found in the UK, Sweden and Germany. Spain, France, and Norway had lower diversities in the range of 0.35. The other countries from Southern Europe and the new member states had the lowest diversities of 0.14 to 0.22.

Table 23: Shannon's Diversity Index for the countries of origin of the doctoral students by country of the team

Country	Arithmetic mean	95% Confidence interval of the mean		No. of teams
		lower bound	upper bound	
CZ	0.19	0.07	0.31	25
DE	0.60	0.48	0.73	54
ES	0.35	0.19	0.52	36
FR	0.33	0.22	0.45	50
HU	0.22	0.07	0.38	30
IT	0.16	0.08	0.24	48
NO	0.33	0.19	0.47	35
PT	0.14	0.05	0.24	38
SE	0.65	0.48	0.82	39
UK	0.70	0.58	0.82	71
Total	**0.41**	**0.36**	**0.45**	**426**

F-Test on the congruence of means: F-value 11.622, $p<0.01$
Levene-Test on the homogeneity of variances: 5.374, $p<0.01$
Robust tests on the congruence of means: Welch-Test: 12.190, $p<0.01$, Brown-Forsythe-Test: 12.205, $p<0.01$

Source: NetReAct survey.

The Shannon Diversity Indices for the countries of last degree of the student differentiated by the country of the team are in most cases very similar to the above results (see table A-9 in the annex). However, there is one notable difference: for Portuguese teams the diversity index is nearly twice as high for the country of last degree as for the country of origin. In other words, the diversity and "foreignness" of the degree is higher than that of birth in Portuguese teams. Closer inspection shows, that this is mainly caused by the fact that students of Portuguese origin studied at undergraduate level in other European countries and some came back to Portugal for the PhD. To some extent an opposite trend can be found for the UK: students went to the UK already at undergraduate level and stayed there for the PhD.

Differentiating doctoral students by their country of origin and the main discipline of the team we see that above all in biosciences teams students from other European countries and North America were recruited (see table 24, the same result is obtained if the country of the graduation is used, see table A-10).

Table 24: Percentages of doctoral students by their country of origin and the main discipline of the team

Main discipline of the team	Country of origin of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
Biology	76.5%	7.2%	1.9%	1.9%	12.5%	264
Biosciences	76.1%	10.6%	2.8%	1.9%	8.6%	686
Biomedicine	80.0%	9.1%	1.8%	1.8%	7.3%	55
Neurosciences	84.0%	8.0%	1.3%	0.0%	6.7%	75
Others	80.6%	8.9%	2.4%	1.6%	6.5%	124
Multiple disciplines	76.2%	8.0%	1.5%	0.8%	13.5%	399
Total	**77.0%**	**9.1%**	**2.2%**	**1.5%**	**10.2%**	**1,603**

Source: NetReAct survey.

Older teams employed less doctoral students from their own country and more students from abroad than teams that were up to 15 years old (see table 25). In particular students from the US, other EU countries, and other countries worldwide rather worked in the older teams. The percentages for the country of last degree are similar (see annex table A-11). Team size and the countries of PhD students do not seem to be related (see annex tables A-12 and A-13).

Table 25: Percentages of doctoral students by their country of origin and the age of the team

Age of the team	Country of origin of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
up to 5 years	79.1%	6.4%	4.0%	1.6%	8.8%	249
6-10 years	79.4%	8.1%	1.3%	1.1%	10.1%	456
11-15 years	79.4%	9.7%	2.8%	0.5%	7.6%	393
16-25 years	72.9%	10.9%	1.0%	2.8%	12.4%	387
more than 25 years	68.3%	10.8%	2.9%	0.7%	17.3%	139
Unknown	82.1%	8.9%	3.6%	1.8%	3.6%	56
Total	**77.0%**	**9.1%**	**2.2%**	**1.4%**	**10.2%**	**1,680**

Source: NetReAct survey.

For team age we also obtain significant differences for the Shannon Diversity Index (see above on the formula). In particular, young teams had a low diversity and teams older than 15 years had a higher diversity in regard to the countries from which they recruited their PhD students (see table 26). This is probably a result of increasing recognition and visibility.

Table 26: Shannon's Diversity Index for the countries of origin of the doctoral students by age of the team

Age of the team	Arithmetic mean	95% Confidence interval of the mean		No. of teams
		lower bound	upper bound	
up to 5 years	0.28	0.18	0.39	78
6-10 years	0.39	0.30	0.47	113
11-15 years	0.39	0.30	0.49	92
16-25 years	0.51	0.41	0.62	91
more than 25 years	0.56	0.39	0.73	34
Unknown	0.36	0.08	0.63	13
Total	**0.41**	**0.36**	**0.45**	**421**

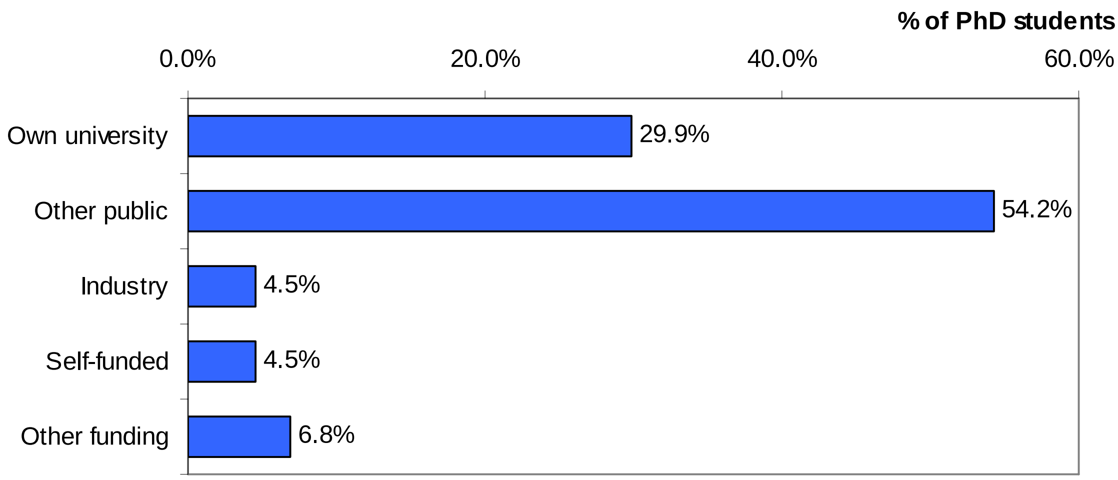
F-Test on the congruence of means: F-value 2.824, $p<0.05$
Levene-Test on the homogeneity of variances: 0.476, insignificant at $p<0.1$
Robust tests on the congruence of means: Welch-Test: 2.716, $p<0.05$, Brown-Forsythe-Test: 1.980, $p<0.1$

Source: NetReAct survey.

4.1.5 Sources and duration of funding

Last but not least the sources and the duration of funding of the PhD students were assessed. More than half of the doctoral students obtained funding from other public sources than their university (c.f. figure 11). University funding was given to 30% of the students. Other sources, industry funding and self-funding by the student were only relevant for 4-7% of the PhD students.

Figure 11: Percentages of doctoral students by their source of funding



Source: NetReAct survey.

Funding structures differed notably across countries (c.f. table 27):

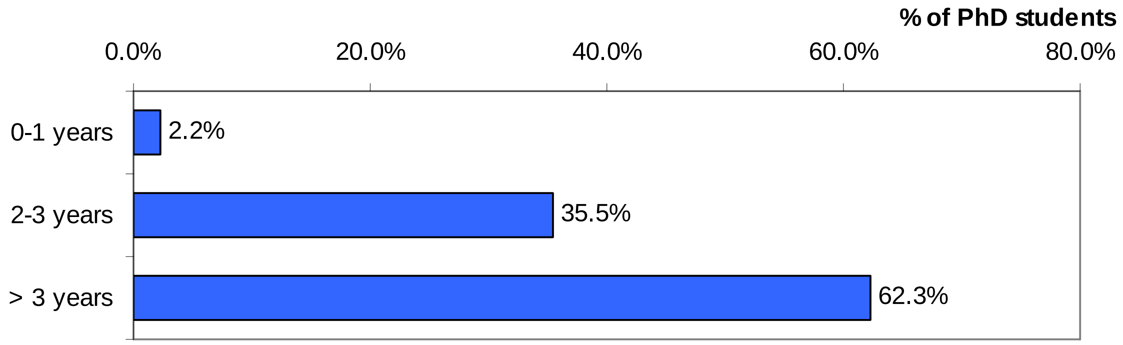
- Funding through the own university was central in Italy, the Czech Republic, and Hungary where other public sources were a lot less important. In the latter two countries, industry and other funding were also unimportant.
- In all countries except for the three listed in the previous bullet point other public sources were the main source of PhD funding. In Portugal it was nearly the only source of funds for doctoral students, besides a little bit of self-funding and university funding.
- Significant industry funding of PhDs was only given in France and the UK.
- Self-funding appeared in particular in the UK and Czech Republic; other funding sources were also available in the UK, France, and Germany.
- Taken together, it seems that the largest variety of funding sources was provided to PhD students in Great Britain and France.

Table 27: Percentages of doctoral students by their source of funding and country of the team

	Source of funding of the doctoral students					
Country of the team	**Own university**	**Other public**	**Industry**	**Self-funded**	**Other funding**	**All students**
CZ	57.3%	26.0%	0.0%	16.7%	0.0%	96
DE	19.5%	65.2%	2.3%	2.7%	10.4%	221
ES	9.6%	74.0%	3.8%	3.8%	8.7%	104
FR	22.4%	51.5%	9.7%	4.6%	11.7%	196
HU	63.6%	25.2%	3.7%	4.7%	2.8%	107
IT	60.7%	31.3%	5.5%	0.6%	1.8%	163
NO	27.0%	62.2%	6.3%	0.9%	3.6%	111
PT	5.5%	85.0%	0.0%	6.3%	3.1%	127
SE	33.9%	55.8%	2.4%	2.4%	5.5%	165
UK	20.2%	56.3%	6.9%	6.1%	10.5%	277
Total	**29.9%**	**54.2%**	**4.5%**	**4.5%**	**6.8%**	**1,567**

Source: NetReAct survey.

Figure 12: Percentages of doctoral students by their duration of funding



Source: NetReAct survey.

The main duration of funding for PhD research is more than 3 years (c.f. figure 12). Short term funding of up to one year is practically inexistent, and funding periods of less than two years are less common, too.

The variance of the duration of funding variable is rather low (c.f. table 28). The funding for PhD students is usually acquired for a minimum period of two years. Short term funding played a negligible role in all countries. Moreover, table 28 reveals that in the large countries DE, FR, IT and UK shorter funding periods of 2-3 years were more common than in the other, smaller countries.

Table 28: Percentages of doctoral students by their duration of funding and country of the team

Country of the team	Duration of funding of the doctoral students			All PhD students
	0-1 years	2-3 years	> 3 years	
CZ	5.8%	33.7%	60.5%	86
DE	2.4%	50.2%	47.3%	205
ES	3.0%	16.2%	80.8%	99
FR	1.5%	44.1%	54.4%	195
HU	1.9%	36.4%	61.7%	107
IT	1.2%	56.8%	42.0%	162
NO	0.0%	20.0%	80.0%	110
PT	4.0%	11.2%	84.8%	125
SE	5.5%	9.1%	85.4%	164
UK	0.0%	46.2%	53.8%	266
Total	**2.2%**	**35.5%**	**62.3%**	**1,519**

Source: NetReAct survey.

Table 29: Percentages of doctoral students by their source of funding and main discipline of the team

Main discipline of the team	Source of funding of the doctoral students					All PhD students
	Own university	Other public	Industry	Self-funded	Other funding	
Biology	34.0%	52.2%	6.3%	2.4%	5.1%	253
Biosciences	32.3%	53.1%	3.8%	3.6%	7.2%	665
Biomedicine	20.8%	64.6%	4.2%	2.1%	8.3%	48
Neurosciences	16.4%	61.8%	3.6%	5.5%	12.7%	55
Others	22.2%	59.5%	4.0%	9.5%	4.8%	126
Multiple disciplines	28.5%	53.7%	5.1%	5.9%	6.9%	376
Total	**29.9%**	**54.3%**	**4.5%**	**4.5%**	**6.8%**	**1,523**

Source: NetReAct survey.

Own university funding is slightly more often obtained in biology and biosciences teams and other public funding in the biomedicine and neurosciences teams and in teams with an emphasis on other sciences outside of the life sciences (c.f. table 29). Industry funding is overrepresented in biology and multidisciplinary teams, but it is till at a low level. Among neurosciences teams funding periods of up to three years are more common than in the other disciplines, but a clear pattern of funding duration cannot be discerned (see table A-14 in the annex).

The importance of own university funding for PhD students is bigger for young teams than for old teams (c.f. table 30). Older teams fare better in obtaining funding from other public sources or industry. This is in good fit with the results on funding sources and team size (c.f. table 31): own university funding is more common in small teams and industry funding in big teams. The results on the duration of funding are reproduced in the annex (see tables A-15 and A-16).

Table 30: Percentages of doctoral students by their source of funding and age of the team

Age of the team	Source of funding of the doctoral students: Own university	Other public	Industry	Self-funded	Other funding	All PhD students
up to 5 years	37.1%	50.9%	3.6%	4.9%	3.6%	224
6-10 years	30.6%	52.3%	3.8%	2.9%	10.5%	421
11-15 years	33.1%	53.1%	4.4%	5.0%	4.4%	360
16-25 years	22.8%	61.4%	3.7%	5.5%	6.6%	347
more than 25 years	25.4%	53.7%	9.7%	4.5%	6.7%	134
Unknown	28.1%	54.4%	5.3%	8.8%	3.5%	57
Total	**29.8%**	**54.5%**	**4.5%**	**4.6%**	**6.6%**	**1,543**

Source: NetReAct survey.

Table 31: Percentages of doctoral students by their source of funding and size of the team

Total staff of the team	Source of funding of the doctoral students: Own university	Other public	Industry	Self-funded	Other funding	All PhD students
less than 10	31.9%	52.4%	4.3%	2.9%	8.6%	489
10 to 19	30.9%	54.7%	3.1%	5.6%	5.7%	647
20 to 29	18.4%	60.4%	7.1%	8.5%	5.7%	212
30 to 49	29.6%	57.6%	4.0%	1.6%	7.2%	125
50 or more	42.9%	39.3%	10.7%	1.2%	6.0%	84
Total	**30.1%**	**54.1%**	**4.5%**	**4.6%**	**6.7%**	**1,557**

Source: NetReAct survey.

4.1.6 Summary

The section analysed the characteristics that were requested for up to five doctoral students per team. The available characteristics of the doctoral students are:

- age,
- gender,

- main discipline of doctoral research,
- country of origin and last degree,
- and sources and duration of funding.

Each of these characteristics was cross-tabulated with the following team characteristics:

- country,
- main discipline of research,
- age,
- and size (total staff members).

The most notable results of this exercise are the following:

1) Doctoral students in the life sciences in the ten sample countries were on average 27.4 years young. The age was higher in the Nordic countries of the sample and lower in the UK. It was also higher in biomedicine and lower in the neurosciences.

2) The majority of PhD students for which information was provided were female: 820 out of 1,553 (52.8%). In Portuguese and Italian research teams more than 60% of the PhD students were females, whereas in British teams there were more males than females. Males were also overrepresented in biomedical teams and teams with a major focus in other sciences (outside of the life sciences) and in small teams of less than ten members. Females were overrepresented in the neurosciences and in teams with 10-29 members.

3) A lot of PhD research in the sample countries was done in biology and the biosciences. Practically every country is well represented in both disciplines. Biomedical research was also present in every country, but more than 25% of the PhD students studied for a PhD in this discipline in the UK. Doctoral students in biomedicine also work more often in multi-disciplinary teams than doctoral students in the other disciplines. PhD research in the neurosciences was important in France, Hungary, and Germany.

4) More than three out of four PhD students studied for a PhD in their country of origin, and nearly 80% in the same country in which they graduated. In general, the figures for country of origin and country of last degree hardly differ. The majority of foreign born (or educated) PhD students in the sample countries had come from another EU country or another country outside of Europe. More students from Romania (30 students, or 1.8% of all PhD students) or China (22 students, 1.3%) studied in the ten countries than from the United States (17 students, 1.0%). Students from abroad could be found particularly in the UK, Sweden, and Germany. The “sending countries” differed: foreign life sciences PhD students were coming to Germany in particular from European countries outside of the EU, and to the UK and Sweden from all over the world. The country-related diversity of PhD students was lowest in Italy, Portugal, Czech Republic and Hungary. Foreign students were recruited especially by teams in the biosciences. As a rule, they also rather worked in older – and presumably more established – teams.

5) PhD research was to 30% funded through university budgets and to more than 50% through other public sources. The importance of university versus other public funding was reversed in Italy, the Czech Republic, and Hungary. University funding was more important for younger and smaller teams. Industry funding, self-funding (by the student) and other sources were generally of low importance. Only in France and the UK was industry funding of PhD students a little bit more common. Funding periods were usually longer than three years, and short term funding of less than one year was negligible.

4.2 PhD graduates who have left the teams since 2003

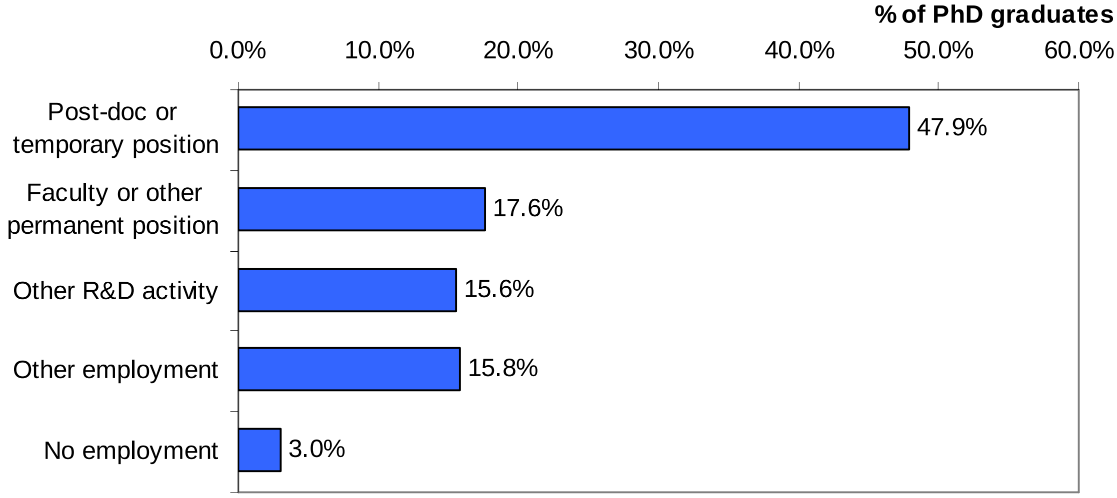
An implicit contract governs the relationship between the research team leaders and their PhD students (see D1.1, pp. 19-20 in more detail): Doctoral students contribute with their work to research programmes increasing the reputation of their supervisors. The students usually do not receive full compensation for this during their PhD but afterwards, when the supervisors and the projects they did under their guidance help them to obtain follow-up positions (Mangematin, 2000; Stephan & Levin, 1997, 2001a). This contract is broken when PhD supervisors do not support the further careers of their students. In such research teams the costs and benefits of PhD degrees become unbalanced. As a consequence these teams should become less attractive for very qualified PhD students.

The fulfilment of the implicit contract was operationalised through collecting information on the new positions of five PhD students who most recently had left the team. We asked the respondents to include all who had left, no matter whether the PhD had been completed or not. The exploratory interviews showed that the respondents usually knew quite well where there former students had gone and what they were doing (see D1.1, p. 69). We assume a quality ranking of the new positions and countries (Mangematin, 2000; Stephan & Levin, 1997): A PhD above all is needed – and therefore provides maximum value – for a career in academia and other public research; it is of less value in private business research and if the PhD works in an entirely different area; and it is useless or even counterproductive, if the PhD graduate is unemployed. Also, we assume that positions in countries with a developed academic environment in the life sciences or a developed biotechnological and medical industry are more attractive to the graduates, as they increase their job opportunities afterwards.

4.2.1 New activities

According to the knowledge of the respondents, the team leaders of the life sciences teams, more than 80% of their former doctoral students – for simplicity reasons we will call them PhD graduates, though we explicitly asked the respondents to include the unsuccessful students, too – continue in R&D (c.f. figure 13). Nearly half have started a post-doc or other temporary position, 18% have obtained a faculty or other permanent position and 16% have engaged in another R&D activity. The same percentage has taken a different kind of employment outside of R&D and merely 3% had no employment after the PhD.

Figure 13: Percentages of PhD graduates by their new activity



Source: NetReAct survey.

However, as table 32 shows, this varies across countries. Temporary positions are less common for graduates from Czech or Hungarian teams and more common in Italy, Portugal and the UK. Permanent positions are most often obtained in Hungary, and still important in France, Portugal and the Czech Republic, whereas they hardly play a role in Sweden and they are less frequent in Germany. The category “Other R&D activity” is of similar importance in all countries only in Sweden it is slightly more common. One third of the PhD graduates of German teams seek employment outside of R&D or they are unemployed.

Table 32: Percentages of PhD graduates by their new activity and country of the team

Country of the team	New activity of the PhD graduates: Post-doc or temporary position	Faculty or other perma-nent position	Other R&D activity	Other employ-ment	No employ-ment	All PhD graduates
CZ	34.1%	22.7%	17.0%	25.0%	1.1%	88
DE	43.7%	9.1%	13.2%	27.9%	6.1%	197
ES	43.4%	17.9%	17.9%	20.8%	0.0%	106
FR	50.3%	25.1%	12.0%	9.9%	2.6%	191
HU	33.7%	38.5%	16.3%	8.7%	2.9%	104
IT	60.3%	13.2%	11.0%	13.2%	2.2%	136
NO	46.4%	16.5%	19.6%	12.4%	5.2%	97
PT	54.7%	22.1%	14.7%	6.3%	2.1%	95
SE	49.6%	5.0%	22.3%	17.3%	5.8%	139
UK	52.3%	16.0%	16.0%	14.1%	1.5%	262
Total	**47.9%**	**17.6%**	**15.6%**	**15.8%**	**3.0%**	**1,415**

Source: NetReAct survey.

Differentiating the PhD graduates by their new activity and the main discipline of their team also produces some interesting insights (c.f. table 33). In the biosciences we find an overrepresentation of temporary positions and an underrepresentation of permanent positions. The opposite applies to biomedical teams and teams in other disciplines. PhD graduates from multidisciplinary teams are particularly often without employment – however, only 43 graduates were classified as unemployed and the 16 coming from multidisciplinary teams still only constitute 4.6% of their graduates. The results on team age and team size for this variable are shown in the annex (tables A-17 and A-18).

Table 33: Percentages of PhD graduates by their new activity and the main discipline of the team

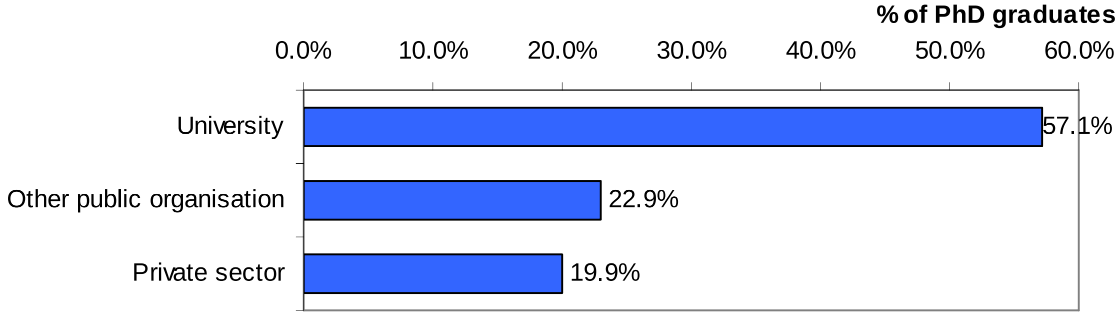
Main discipline of the team	New activity of the PhD graduates					All PhD graduates
	Post-doc or temporary position	Faculty or other perma-nent position	Other R&D activity	Other employ ment	No employ-ment	
Biology	42.3%	19.2%	18.8%	16.3%	3.4%	208
Biosciences	57.6%	11.8%	14.4%	14.0%	2.2%	592
Biomedicine	26.3%	39.5%	18.4%	13.2%	2.6%	38
Neurosciences	46.9%	25.0%	6.3%	18.8%	3.1%	64
Others	31.6%	26.3%	20.2%	19.3%	2.6%	114
Multiple disciplines	41.3%	21.1%	15.4%	17.7%	4.6%	351
Total	**47.5%**	**17.9%**	**15.5%**	**15.9%**	**3.1%**	**1,367**

Source: NetReAct survey.

4.2.2 New organisations

In addition to the new activities of the graduates another question asked for the new organisations in which they continue to work after leaving the team of their PhD research. Nearly six out of ten continue to work in a university, and 20% have moved on to other public organisation respectively the private sector (c.f. figure 14).

Figure 14: Percentages of PhD graduates by their new organisation



Source: NetReAct survey.

There are some country differences for this variable, too (table 34): in France graduates particularly often join other research organisations in the public sector like CNRS, INSERM or INRA and in Spain the CSIC. Among those who go to the private sector we find above all graduates from Germany, whereas this transition after the PhD is nearly inexistent in Hungary and Portugal.

Table 34: Percentages of PhD graduates by their new organisation and the country of the team

Country of the team	New activity of the PhD graduates			All PhD graduates
	University	Other public organisation	Private sector	
CZ	48.8%	24.4%	26.8%	82
DE	50.5%	17.4%	32.1%	184
ES	53.3%	30.5%	16.2%	105
FR	50.8%	30.6%	18.6%	183
HU	76.5%	15.7%	7.8%	102
IT	67.9%	14.5%	17.6%	131
NO	56.8%	26.1%	17.0%	88
PT	63.4%	29.0%	7.5%	93
SE	55.0%	20.6%	24.4%	131
UK	56.3%	22.9%	20.8%	245
Total	**57.1%**	**22.9%**	**19.9%**	**1,344**

Source: NetReAct survey.

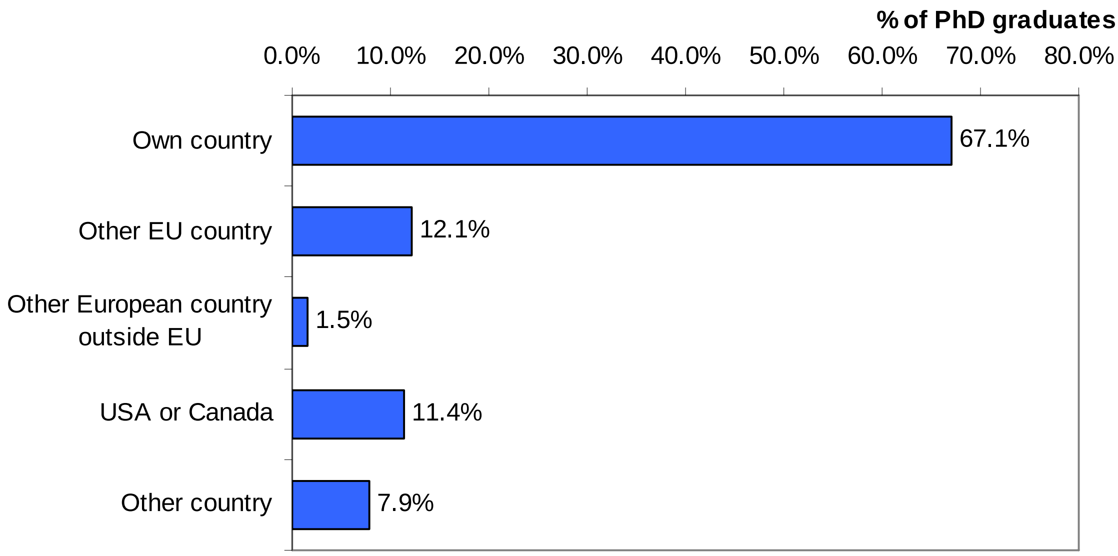
The results for the main academic discipline, the age and size of the teams are not particularly striking (see annex tables A-19 to A-21). One interesting finding is, that PhD graduates moving on to the private sector have studied rather in older than in younger teams (see table A-20, p. 98) – this is in line with the finding on funding sources of PhD research, which are more often industry-based in older teams (see p. 53). Hence, it seems that the connection to the private sector is something that is growing over time.

4.2.3 Countries of destination

Approximately two third of the PhD graduates continued to work in the same country in which they had obtained their PhD, 11-12% went to another EU member state or the US or Canada, and 8% to another country worldwide. Other European countries outside of the EU are hardly chosen at all as new work places.

Comparing the countries of destination with the source countries of PhDs (c.f. figure 9, p. 46) corroborates that the USA are a “net importer” of life science PhDs from the EU (Stephan & Levin, 2001b) – the number of European graduates going to the US is considerably higher than the number of American students coming to Europe for a PhD.

Figure 15: Percentages of PhD graduates by their new country of work



Source: NetReAct survey.

The number of graduates who leaves the country of the PhD research is remarkably high in France (see table 35): it is the only country where more graduates leave (96) than stay (94). Many “leavers” can also be found in UK, Sweden and Spain. French graduates are overrepresented in all other country categories. Like the French, the Swedish graduates also often chose the USA as a new destination. British graduates frequently moved on to the USA or Canada and to other countries at global level.

Table 35: Percentages of PhD graduates by their new country of work and the country of the PhD research

Country of PhD research	Country of destination of the PhD graduates					All PhD graduates
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
CZ	78.4%	12.4%	0.0%	7.2%	2.1%	97
DE	73.1%	9.3%	1.6%	7.8%	8.3%	193
ES	63.0%	15.0%	0.8%	11.8%	9.4%	127
FR	49.5%	18.4%	5.3%	16.8%	10.0%	190
HU	74.8%	10.8%	4.5%	6.3%	3.6%	111
IT	79.3%	10.0%	0.7%	7.9%	2.1%	140
NO	76.0%	6.7%	0.0%	12.5%	4.8%	104
PT	75.7%	14.4%	0.9%	4.5%	4.5%	111
SE	59.9%	10.6%	0.7%	19.7%	9.2%	142
UK	60.5%	11.8%	0.0%	13.7%	14.0%	271
Total	**67.1%**	**12.1%**	**1.5%**	**11.4%**	**7.9%**	**1,486**

Source: NetReAct survey.

According to table 36 the graduates of biosciences teams (molecular biology, cell biology, genetics, biochemistry & biophysics) are particularly mobile: they add up to roughly 40% of all PhD graduates, but they constitute 60% of those going to the US or Canada after the PhD and more than 50% of graduates moving on to another EU country.[5] On the opposite, biology graduates are rather immobile and in particular they go to the US less often than their colleagues in other life sciences fields.

Table 36: Percentages of PhD graduates by new country of work and the main discipline of the team

Main discipline of the team	Country of destination of the PhD graduates					All PhD graduates
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
Biology	74.2%	7.7%	0.0%	6.8%	11.3%	221
Biosciences	60.6%	15.5%	2.1%	16.5%	5.4%	576
Biomedicine	71.4%	7.1%	0.0%	9.5%	11.9%	42
Neurosciences	60.8%	16.2%	1.4%	14.9%	6.8%	74
Others	75.2%	11.5%	0.9%	7.1%	5.3%	113
Multiple disciplines	70.1%	10.2%	1.7%	7.5%	10.5%	361
Total	**66.8%**	**12.3%**	**1.4%**	**11.5%**	**7.9%**	**1,387**

Source: NetReAct survey.

It seems that the long distance relationships to the US or Canada and other countries outside of Europe take some time to be established. Among the teams that are five years old or younger we find comparatively few graduates who went to these destinations than among the older teams (see table 37). The outbound mobility of PhD graduates does not seem to be related to team size (see table A-22 in the annex).

Table 37: Percentages of PhD graduates by new country of work and the age of the team

Age of the team	Country of destination of the PhD graduates					All PhD graduates
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
up to 5 years	70.5%	12.6%	2.2%	8.2%	6.6%	183
6-10 years	63.3%	14.6%	2.1%	13.3%	6.6%	376
11-15 years	65.8%	13.4%	2.4%	10.5%	7.9%	380
16-25 years	67.5%	9.9%	0.3%	13.0%	9.3%	354
more than 25 years	67.6%	11.0%	0.0%	11.0%	10.3%	136
Unknown	91.2%	2.9%	0.0%	0.0%	5.9%	34
Total	**66.9%**	**12.3%**	**1.5%**	**11.3%**	**7.9%**	**1,463**

Source: NetReAct survey.

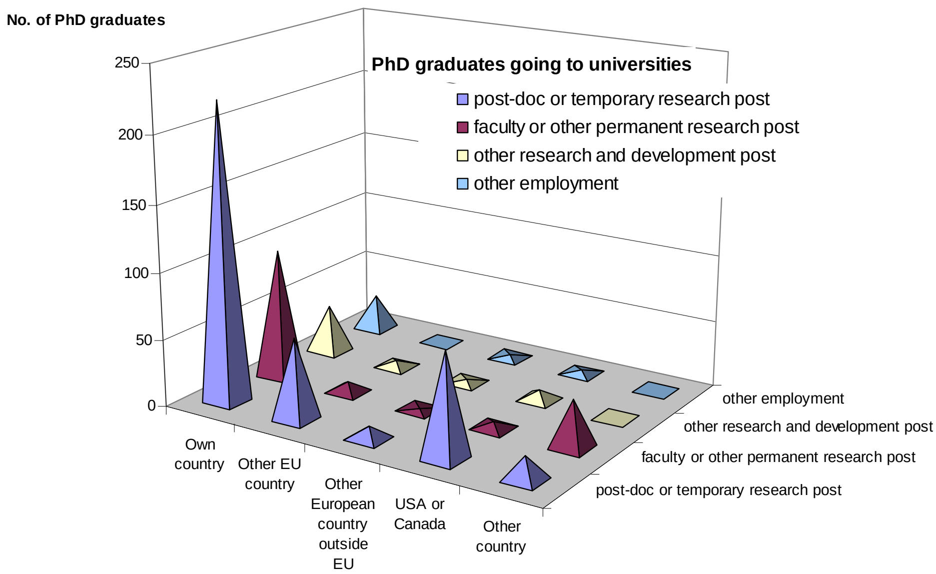
[5] This corroborates what other studies have found, that the new life sciences disciplines are above all affected by outflows of young researchers to the US (c.f. Buechtemann, 2001).

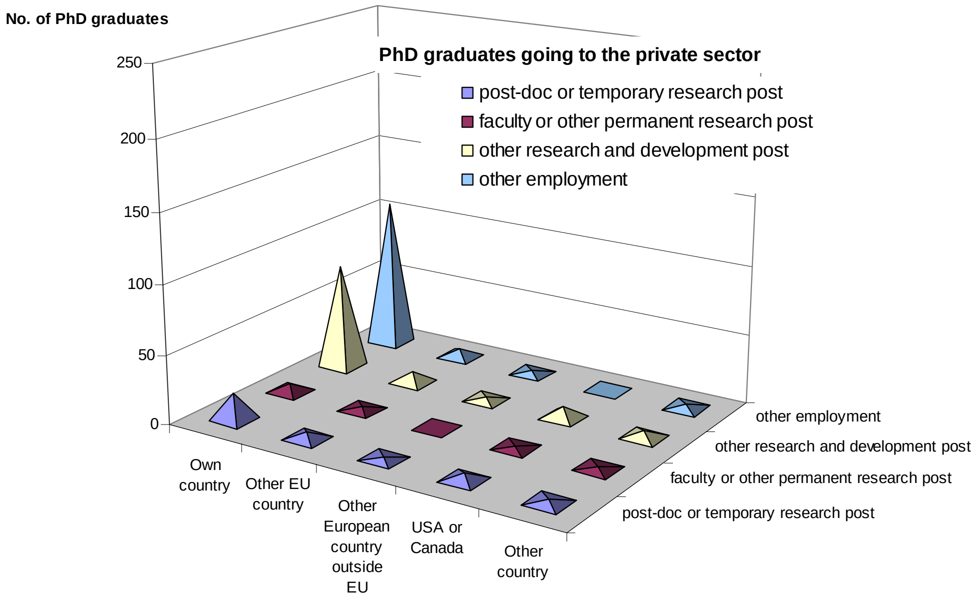
4.2.4 Combinations of activity, organisation and country

There are certain typical combinations of these variables on the destinations of PhD graduates. They are rather similar for PhDs who go to work in universities and in non-university public research organisations and differ from PhDs who go to the private sector see figures 16a-b and figure A-1 in the annex).

PhD 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; some of the graduates get these permanent positions in other countries outside of Europe – we suppose that these are often graduates returning to their home countries, though we don't have any real proof for this (it would require a more detailed biographical analysis). Graduates who obtain another research and development position or employment outside of R&D often leave academia and move to the private sector (see figure 16b).

Figure 16a-b: PhD graduates by their new organisation of work, activity and destination country





Source: NetReAct survey.

4.2.5 Summary

Nearly half of the PhD graduates continued to work in science on temporary positions. Fewer obtained permanent positions, worked in private sector R&D or continued on positions unrelated to research. According to the knowledge of the team leaders 3% did not find any employment after their PhD. Across all ten countries two third of the PhD graduates remain in the same country in which they obtained the PhD. The USA are a much more important destination for PhD graduates than source of PhD students. In particular high percentages of Swedish and French graduates have obtained new positions overseas.

The trajectories of PhD graduates clearly differed across countries. Whereas the typical Hungarian PhD graduate has obtained a faculty or post-doc position at a Hungarian university, French graduates more often have joined a non-university research organisation or left the country and sought a new job abroad. A sizable fraction of German graduates has moved on to research or other employment in the private sector in Germany.

What do these trajectories imply in regard to the fulfilment of the implicit contract between team (leader) and PhD student? We found that German, Swedish and Czech PhD graduates often have left science. They have taken jobs in the private sector and outside of research instead. This might indicate that public science cannot absorb all the PhDs and meet the career expectations of the PhD students in these countries. This, indeed, would indicate that a problem in regard to the implicit contract exists. The comparatively large percentages of non employed graduates in Germany and Sweden support this reading. However, a different explanation would be that conventions in regard to the role and value of a PhD might differ across Europe and that in the mentioned countries a PhD degree is often considered as the ticket to a career in industry. We cannot definitely answer this question, as a closer inspection of the motivations of PhD students would be required. However, the ongoing analysis of post-docs (WP 3) should produce some further results on their professional trajectories which can be compared with the findings on PhD graduates.

4.3 Recruitment of doctoral students

In order to get some more background information on the recruitment of doctoral students the NetReAct questionnaire also included questions on the factors that helped the groups to attract the right type and number of applicants for PhD studentships and the sought characteristics of these applicants.

4.3.1 Factors determining the attractiveness of teams

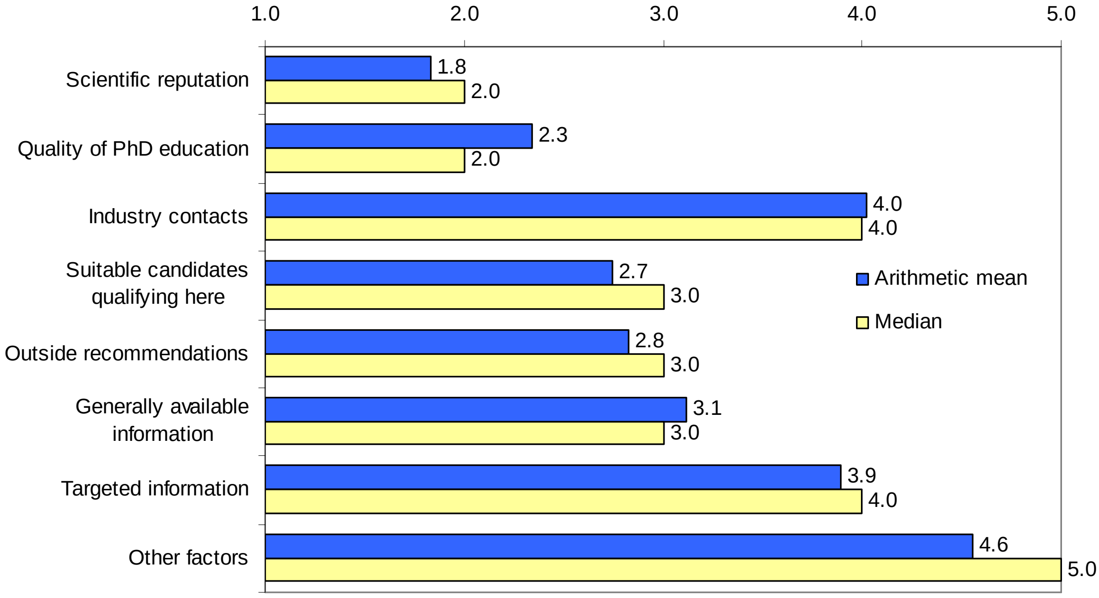
According to the opinion of our respondents the attractiveness of their team for new PhD students was mainly determined by the team's scientific reputation: the higher the reputation, the easier it was to attract good PhD students (see table 38 and figure 16). The quality of the PhD programme and the availability of suitable graduates from within the university were also deemed very important or important by the majority of respondents. Rather unimportant were the mailing of targeted information to other schools, organisations or individuals and industry contacts.

Table 38: Factors determining the attractiveness of groups for PhD students

	essential	very important	important	low importance	no importance	Total responses
Scientific reputation	39.1%	41.0%	17.9%	1.7%	0.2%	458
Quality of PhD education	16.6%	44.8%	29.9%	5.2%	3.5%	458
Industry contacts	1.5%	7.4%	15.5%	38.0%	37.6%	458
Suitable candidates qualifying here	9.0%	34.9%	37.8%	9.4%	9.0%	458
Outside recommendations	7.4%	31.2%	38.4%	17.5%	5.5%	458
Generally available information	7.6%	21.2%	34.7%	25.1%	11.4%	458
Targeted information	2.8%	7.0%	19.2%	39.7%	31.2%	458
Other factors	4.8%	4.8%	3.5%	3.7%	83.2%	458

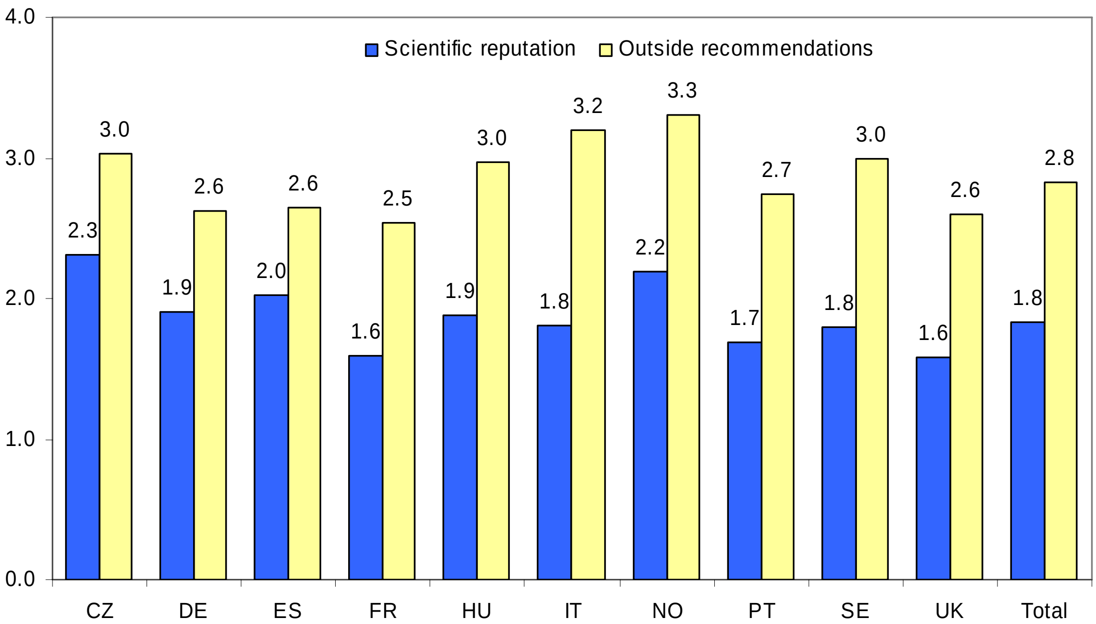
Source: NetReAct (FHSO).

Figure 16: Factors determining the attractiveness of groups for PhD students
(1 = essential to 5 = no importance)



Source: NetReAct survey.

Figure 17: Scientific reputation and outside recommendations as determinants of the attractiveness of groups for PhD students by country of the team
(1 = essential to 5 = no importance)

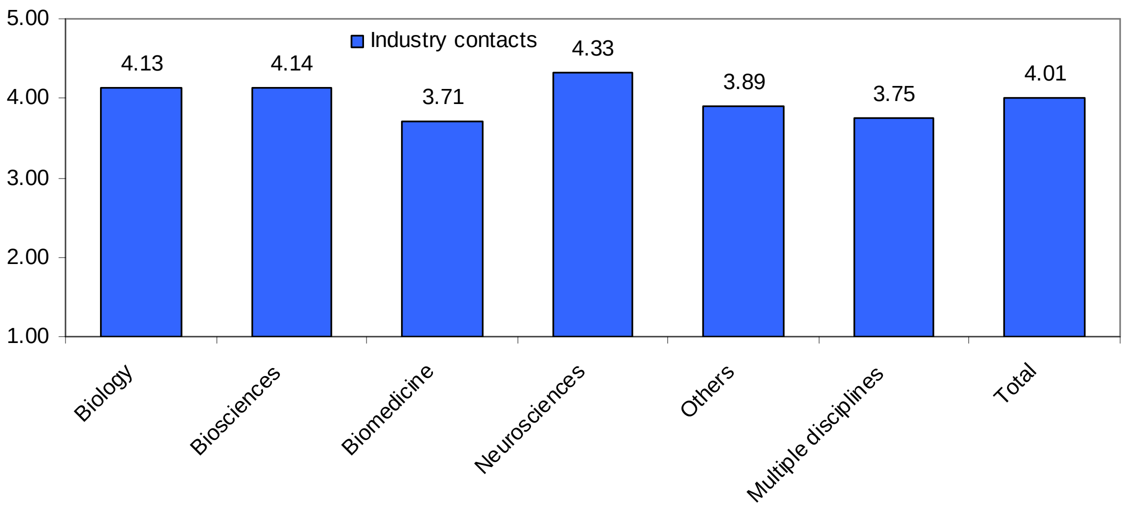


Source: NetReAct survey.

The rankings of these factors differ between the countries in the dataset. All factors receive lower importance ratings in Norway and the Czech Republic, whereas they receive higher ratings in the UK and France (see table A-23 in the annex). In particular the scientific reputation and recommendations from researchers working elsewhere were of lower importance in the former and higher importance in the latter countries (c.f. figure 17). In Norway the quality of the PhD education received also a significantly lower importance rating. In Hungary and the Czech Republic generally available information sources like the internet, newsletters, newspapers and journals were rated lower and in the UK higher than in the ten country average.

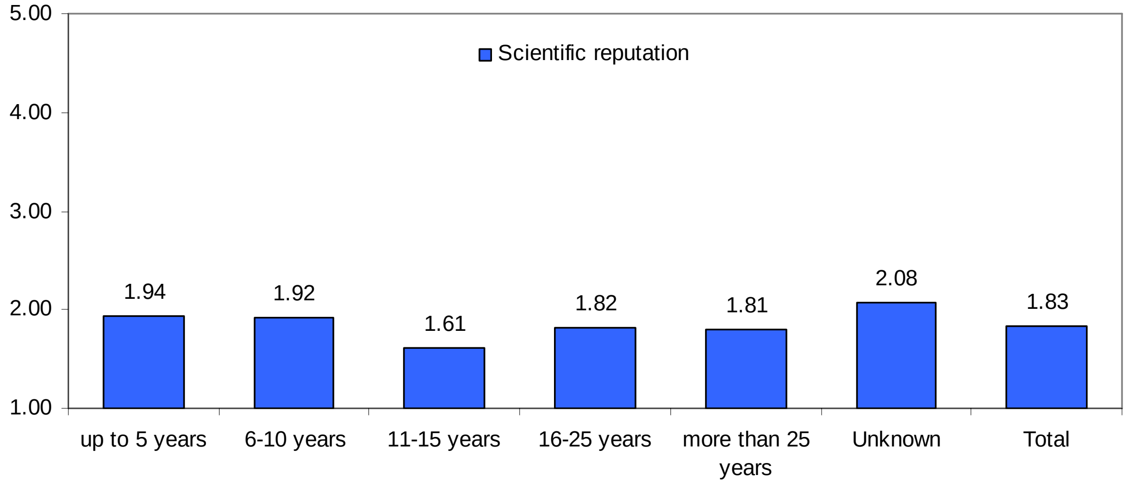
In addition, we also differentiated the attractiveness factors by the main scientific discipline, the age and the size of the team. In most cases, these variables did not relate to the attractiveness factors. Some significant relationships are shown in figures 18-20 (all significant in non-parametric Kruskal-Wallis Tests). Industry contacts were of higher importance for biomedical and multidisciplinary research teams when recruiting new PhD students than for teams from all the other disciplines (figure 18). The scientific reputation was least important for young teams and most important for teams that were between 11 and 15 years old (figure 19). The ratings for industry contacts and suitable candidates graduating at the same university were increasing with team size – except for the largest team size category (which might be somewhat special, as we have stated several times above, see e.g. p. 34).

Figure 18: Industry contacts as a determinant of the attractiveness of groups for PhD students by main discipline of the team (1 = essential to 5 = no importance)



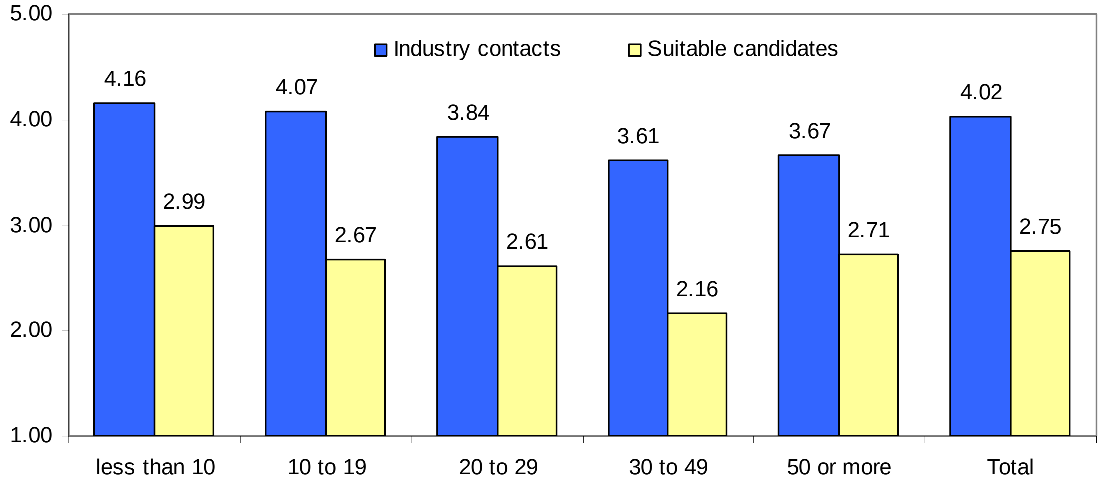
Source: NetReAct survey.

Figure 19: Scientific reputation as a determinant of the attractiveness of groups for PhD students by age of the team



Source: NetReAct survey.

Figure 20: Industry contacts and suitable candidates from the same university as determinants of the attractiveness of groups for PhD students by size of the team



Source: NetReAct survey.

4.3.2 Desired characteristics of applicants

The exploratory interviews carried out before the survey had shown that qualifications, skills, motivation, and how well applicants seemed to fit into the team were important issues considered in the filling of open PhD positions (see NetReAct deliverable 1.1, p. 66). These preliminary findings were translated into survey questions which aimed to produce a broader and better founded picture of the desired characteristics of PhD students influencing the team leaders' recruitment decisions. Eleven different characteristics were listed in the questionnaire plus an open-ended question to capture additional issues (see annex 2, p. 108 on the question).

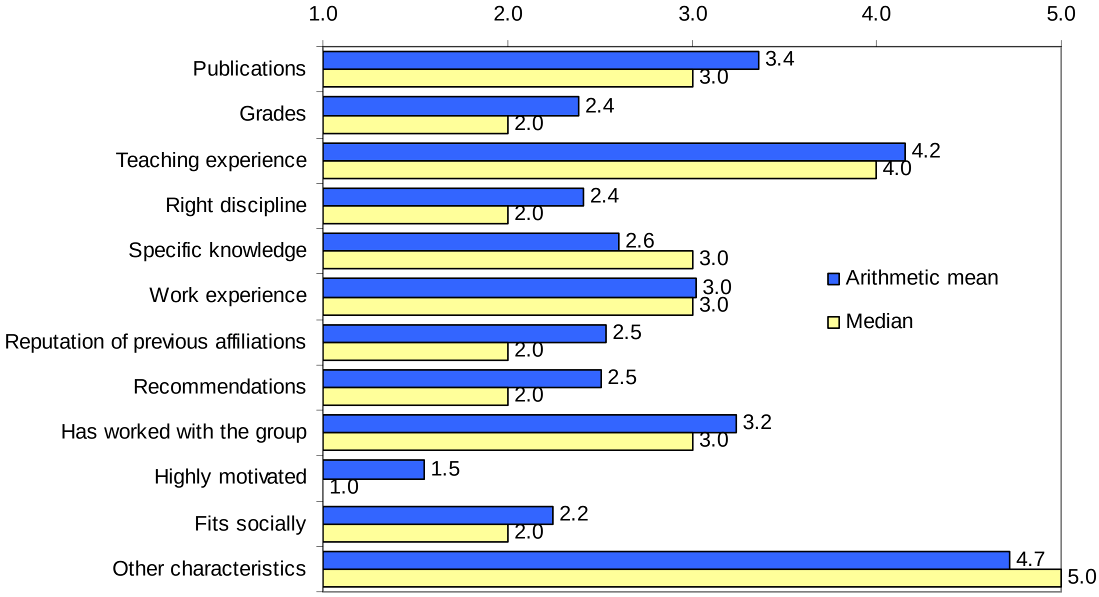
The responses for the entire set of teams are reproduced in table 39 and figure 21. We see that by far the most influential criterion in the selection of applicants is their motivation to work with the group and on the topics it covers. More than half of the respondents considered this as essential (c.f. table 39). With some distance follow the applicants expected social fit into the team, their grades and discipline, the reputation of previous affiliations and recommendations from colleagues. Teaching experience was considered the least important influence (besides the "others" category).

Table 39: Desired characteristics of applicants for PhD studentships

	essential	very important	important	low importance	no importance	Total responses
Publications	6.3%	13.2%	32.6%	34.3%	13.6%	463
Grades	18.4%	36.9%	35.2%	6.7%	2.8%	463
Teaching experience	0.6%	1.7%	14.7%	47.7%	35.2%	463
Right discipline	16.8%	37.1%	36.1%	8.0%	1.9%	463
Specific knowledge	12.7%	32.8%	38.7%	12.7%	3.0%	463
Work experience	3.9%	25.5%	40.2%	25.7%	4.8%	463
Reputation of previous affiliations	11.2%	41.9%	33.5%	9.3%	4.1%	463
Recommendations	11.0%	43.8%	32.0%	9.9%	3.2%	463
Has previously worked with the group	6.5%	20.5%	28.7%	31.5%	12.7%	463
Highly motivated	57.0%	33.7%	8.0%	0.0%	1.3%	463
Fits socially	22.9%	40.4%	28.7%	5.4%	2.6%	463
Other characteristics	3.5%	2.8%	2.4%	0.6%	90.7%	463

Source: NetReAct (FHSO).

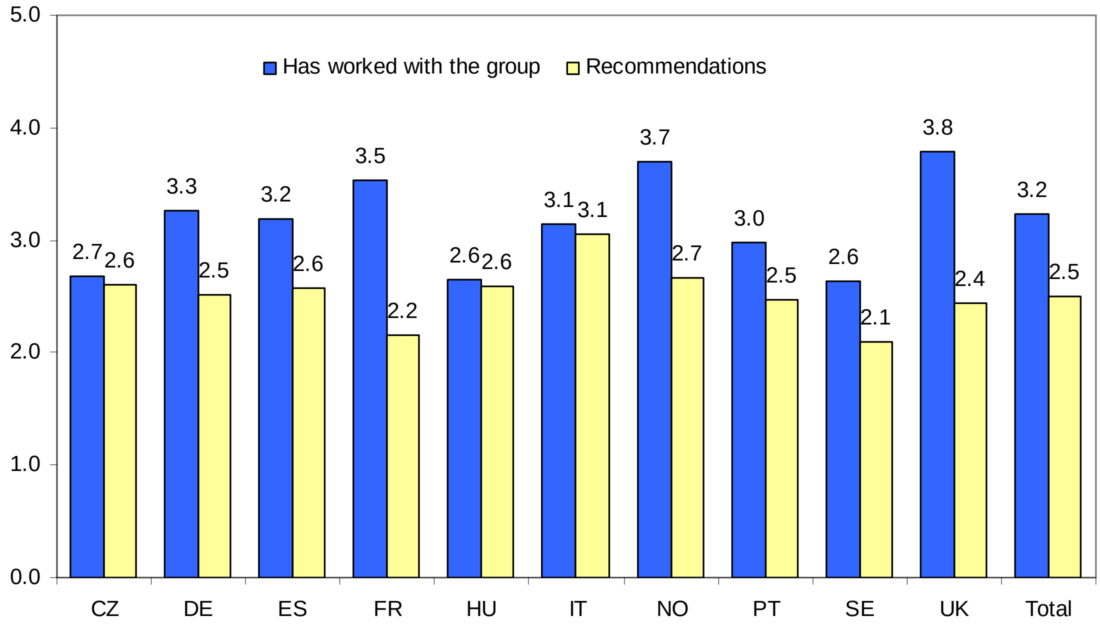
Figure 21: Desired characteristics of applicants for PhD studentships
(1 = essential to 5 = no importance)



Source: NetReAct survey.

There are also notable variations between the countries in the sample for these characteristics (see table A-24 in the annex). Team leaders from Germany rated most factors higher than their colleagues – especially teaching experience and social fit into the team – whereas Czech team leaders highlighted the role of publications but otherwise gave lower importance ratings for most characteristics. Czech respondents rated publications and grades identically, in contrast to British respondents who attributed nearly two times as much influence to grades than to publications in the admission of doctoral students. Most differences between the ratings were found for the two characteristics shown in figure 22. In the UK, Norway and France it is considered of low importance whether an applicant has previously worked with the team, whereas it is deemed a lot more important in Sweden, Hungary and the Czech Republic. Scholars relied more on the recommendations of well-regarded colleagues in Sweden and France, and they paid less heat to these above all in Italy.

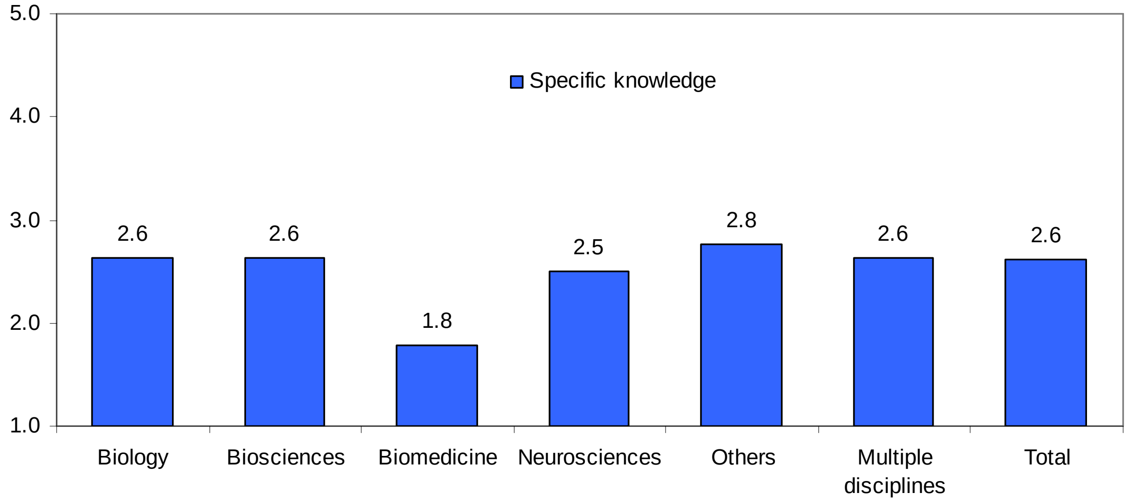
Figure 22: Having worked with the team previously and recommendations from well-regarded colleagues by country of the team
(1 = essential to 5 = no importance)



Source: NetReAct survey.

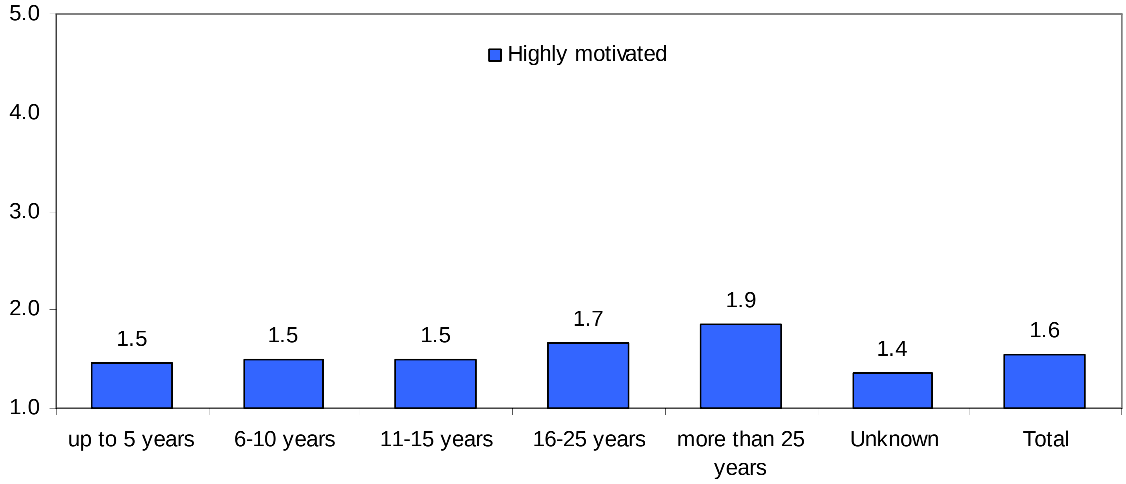
We investigated whether the main scientific discipline of the team, as well as its age and size also played a role in the recruitment decisions and influenced at which characteristics of the applicants the team leaders looked. We might assume, for instance, that in larger teams the social fit into the team played a lesser role, or that older teams were less apprehensive of the reputation of other teams. However, there are only few differences in the ratings between disciplines, age and size groups and neither of the two mentioned hypotheses can be confirmed, at least not at conventional levels of significance. Figures 23-25 depict the most recognisable (and significant) differences. It is notable, that in biomedical research teams specific knowledge of the applicants is valued higher (c.f. figure 23). The importance of a high motivation to work on certain topics decreases with the age of the team, which is possibly due to a broader range of topics in older teams (figure 24). Last but not least there are rises in the importance of publications and previous group-specific work experience for teams in the middle size group of 20-29 members (translated into a dip in figure 25, as the lower the number the higher the rating). We have no explanations for these rises.

Figure 23: Importance of specific knowledge for recruiting by main discipline of the team (1 = essential to 5 = no importance)



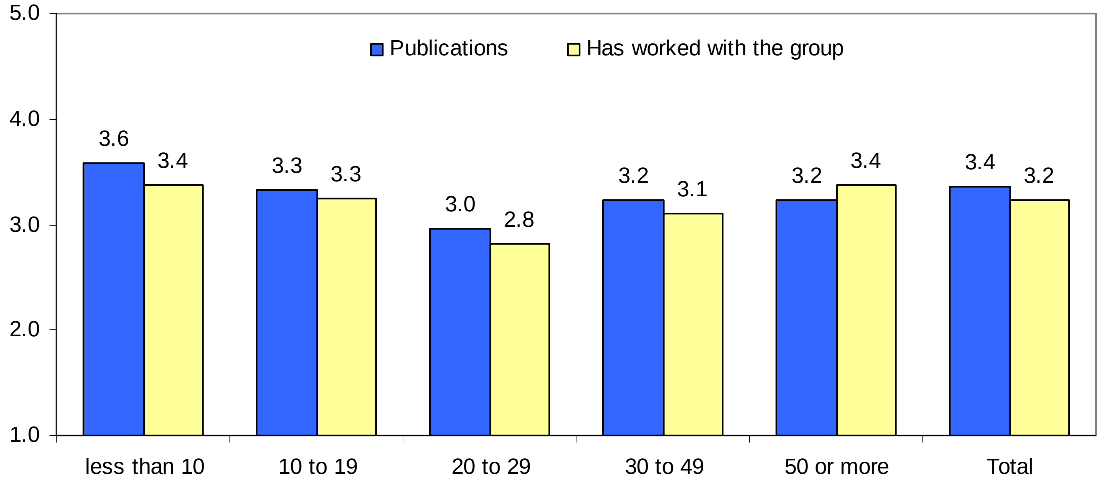
Source: NetReAct survey.

Figure 24: Importance of a high motivation for recruiting by size of the team (1 = essential to 5 = no importance)



Source: NetReAct survey.

Figure 25: Importance of publications and previous work experience with the group for recruiting by size of the team (1 = essential to 5 = no importance)



Source: NetReAct survey.

4.3.3 Graduate schools

Graduate schools are a means of combining the effort of recruiting and training graduate students among different institutions and persons. Doctoral students are usually sought after the graduate school has been established and funding has been secured. The survey also assessed whether the teams were attached to such a graduate school. Nearly three quarter of the teams (73.5%) stated that they were, whereas 26.5% said that they were not (see table 40).

Table 40: Percentages of teams associated with a graduate school by country of the team

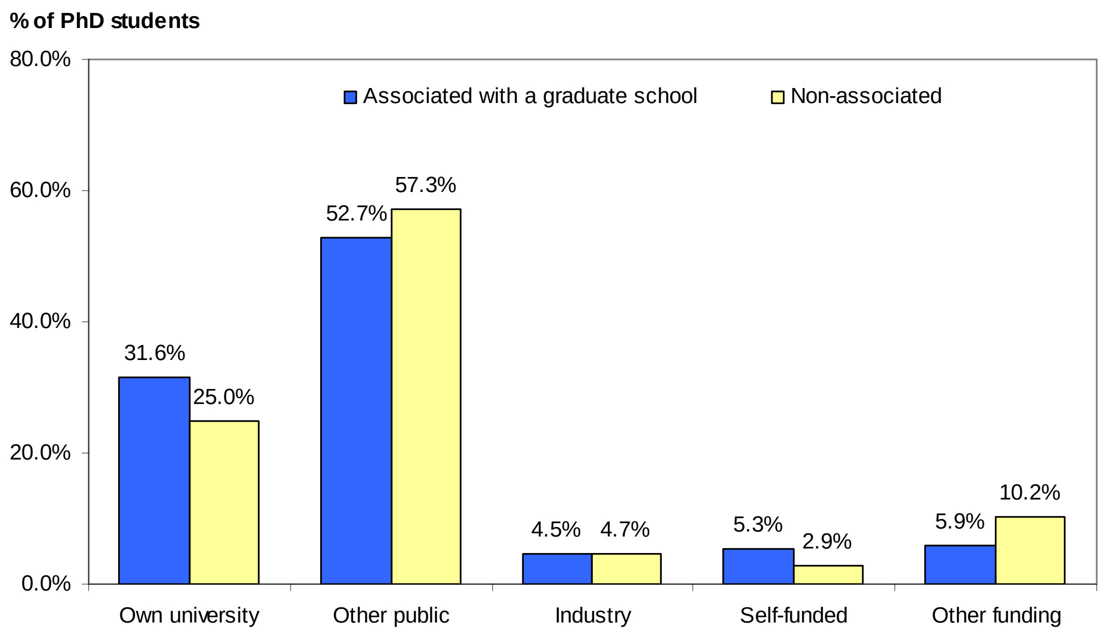
Country of the team	Associated with a graduate school					
	Yes		No		All teams	
	N	In %	N	In %	N	In %
CZ	28	93.3%	2	6.7%	30	100.0%
DE	24	46.2%	28	53.8%	52	100.0%
ES	26	74.3%	9	25.7%	35	100.0%
FR	49	94.2%	3	5.8%	52	100.0%
HU	31	93.9%	2	6.1%	33	100.0%
IT	34	69.4%	15	30.6%	49	100.0%
NO	25	69.4%	11	30.6%	36	100.0%
PT	35	79.5%	9	20.5%	44	100.0%
SE	25	61.0%	16	39.0%	41	100.0%
UK	53	68.8%	24	31.2%	77	100.0%
Total	**330**	**73.5%**	**119**	**26.5%**	**449**	**100.0%**

Source: NetReAct survey.

The responses varied across countries (c.f. table 40): In France, Hungary and the Czech Republic nearly all teams were associated with a graduate school. In all the other countries except for Germany still the majority of the teams participated in a graduate school – only in Germany the graduate school type of doctoral training was not as widespread. We do not find any significant relationship between the main scientific disciplines, ages and sizes of the teams and the association with graduate schools. Therefore, the results for these variables are not shown.

Teams associated with a graduate school seem to have had slightly more PhD students than non associated teams – the arithmetic mean is 4.8 versus 4.1 for non-associated teams. However, this result is not even significant at the 10% level and we cannot refuse that the observed difference might be coincidental. Moreover, we investigated whether teams associated with a graduate school were more international and whether they had a different funding structure for their PhD students than teams not associated to a graduate school. The findings for the first variable are negative: the Shannon Diversity Index for associated teams was not higher than for non-associated teams (see p. 48 on the index). The funding structures differ slightly (c.f. figure 26). In particular, teams associated to graduate schools have more PhD students funded from their own university and less funded from other public organisations and other funding sources. However, the differences are small and they might rather reflect national differences (see table 27 on p. 51) than differences which are due to the training system for PhDs.

Figure 26: Percentages of doctoral students by their source of funding and the association of the team with a graduate school



Source: NetReAct survey.

4.3.4 Summary

The present chapter investigated the factors influencing the recruitment of PhD students from two perspectives: the attractiveness of the teams for PhD students and the attractiveness of applicants for open PhD positions.

In regard to the attractiveness of life sciences teams the team leaders highlighted the role of the team's scientific reputation for obtaining highly qualified PhD candidates. Though it would have been better to ask the PhD students themselves, what they judge important, we think that the responses are trustworthy as the team leaders once were PhD students, too. In addition to the scientific reputation the quality of the PhD education plays a major role, whereas industry contacts were hardly rated as important.

The most desired property of applicants is a high degree of motivation and commitment. All other characteristics are considered to be less important, though some still receive a high importance ranking, like whether applicants are expected to fit into the team, their grades, discipline, previous affiliation or recommendations from colleagues.

The appraisals of team and applicant characteristics differ by country. For instance, recommendations play a more pronounced role in France than in the other countries; local candidates and previous knowledge of the applicants are less important in the UK, where PhD students are more mobile and more international than in the other countries (see p. 48). Some of the appraisals also tend to vary between young and old teams as well as between small and large teams.

In all countries except for Germany more than half of the teams were associated to a graduate school. However, this association does not seem to entail any specific consequences in regard to the number or structure (internationality) of PhD students.

5 Doctoral students differentiated by universities

In addition to the analysis at team level the collected data also permits some basic analysis at university level. Overall we found in the ten NetReAct countries a research population of 359 universities with teams in the life sciences (c.f. table 1, p. 17). Out of these 359 universities 304 (85%) were included in the NetReAct sample (c.f. table 2, p. 19). In total, teams from 180 of these universities – 50% of the population – enter the database with usable responses. In addition, some of the respondents provided information on teams of non university research organisations (like Max Planck Society, CNRS, CSIC, Medical Research Council etc.) which they were leading in 2003. Moreover, we integrated the data for the colleges of the University of London. This produced a total of 190 different organisations as the main affiliation.[6] For the majority of these organisations, we only obtained data on 1 or 2 teams which does not permit an aggregation to university level. For those universities for which 3 or more team leaders answered the questionnaire, we calculated some basic statistics on doctoral students which are reproduced in the following chapters (on post-docs see the deliverables of WP 3).

Doctoral students by university

Table 41 shows the average numbers of doctoral students per team by university – few non-university research organisations are included, but for simplicity reasons we will generally speak of universities. The first two columns show great variations of the numbers across the universities. The confidence intervals are large and the means are generally not really dependable.

More interesting are the columns 5-8. These show the ratios of PhD students to total staff of the teams, column 5 as the ratio of all students to all team staff and column 6 as mean of means. To large extent the results reproduce what we already know from the country level analysis (c.f. table 11, p. 36): French, Hungarian and Italian universities had rather small shares of students per team, whereas Swedish universities had large shares. The maximum shares of 50% were obtained at the Ruprecht-Karls-University Heidelberg and the KTH Royal Institute of Technology Stockholm; means with confidence intervals above the overall confidence interval also appear for the universities of Coimbra and Uppsala. Minimum shares of 12-15% had the universities of Milano and Cambridge.

However, we get notable variations within the universities which are expressed in large confidence intervals of the mean. Even for universities with several teams like the Charles University, or the universities of Szeged, Oslo, Bergen, Lisbon, and Uppsala we get large intervals. This suggests that at university level there is probably rarely something like a clear strategy in regard to the team composition and the role of doctoral students which is also realised at team level.

[6] Some teams are affiliated to more than one organisation, in particular in countries like France where mixed units are very common. However, we kept the university affiliation in these cases.

Table 41: Doctoral students per team by university

	Median	Arithmetic mean	95% Confidence interval of the mean Lower[c]	Upper	In % of total staff[a]	In % of total staff (means)[b]	95% Confidence interval of the mean Lower[c]	Upper	Valid cases
Czech Republic									
Charles University, Prague	4	6.1	1.5	10.7	22.4%	24.5%	18.7%	30.2%	13
Masaryk University	2.5	4.3	-1.9	10.4	27.4%	24.7%	8.1%	41.3%	4
Palacky University	6.5	6.5	-2.0	15.0	30.2%	29.0%	15.7%	42.4%	4
Czech Academy of Sciences	4	4.3	-1.9	10.6	38.2%	36.9%	15.7%	58.1%	3
Germany									
Albert-Ludwigs-University Freiburg	3.5	3.3	-1.1	7.6	35.1%	31.2%	-2.3%	64.6%	4
Eberhard-Karls-Universität Tübingen	5	6.3	-4.0	16.7	26.8%	29.4%	11.8%	46.9%	3
Georg-August-Universität Göttingen	3	3.3	1.9	4.8	41.7%	42.7%	11.1%	74.2%	3
Justus-Liebig University Giessen	2	3.0	-3.6	9.6	28.1%	24.9%	-1.2%	51.0%	3
Ludwig-Maximilians-University München	7.5	7.3	3.3	11.2	38.7%	40.6%	30.3%	51.0%	4
Ruprecht-Karls-Universität Heidelberg	4	7.0	-2.1	16.1	50.0%	51.0%	34.2%	67.8%	5
Spain									
Universidad Autónoma de Madrid	2	1.7	0.2	3.1	27.8%	28.4%	-0.6%	57.4%	3
Universidad de Sevilla	5	5.0	0.0	10.0	45.5%	45.2%	11.8%	78.6%	3
Universitat de València	4.5	6.3	-3.4	15.9	37.3%	36.7%	14.9%	58.4%	4
University of La Laguna	4	5.0	-1.6	11.6	32.6%	35.9%	18.2%	53.7%	3
France									
Ecole normale supérieure	10	8.7	-1.7	19.0	29.9%	30.7%	10.7%	50.7%	3
Universite Louis Pasteur, Strasbourg	1	1.7	-1.2	4.5	18.5%	17.2%	4.6%	29.8%	3
Universite Montpellier II	3.5	7.0	-0.9	14.9	23.1%	21.2%	16.2%	26.2%	6
Université Paris-Sud (Paris XI)	3.5	3.3	1.7	4.8	22.8%	26.9%	1.6%	52.3%	4
Universite Paul Sabatier - Toulouse 4	5	4.2	2.8	5.6	25.0%	25.0%	18.1%	31.9%	5
Universite Pierre et Marie Curie Paris 6	1	1.8	-0.6	4.2	22.5%	18.2%	3.8%	32.5%	5
CNRS	3	5.0	-0.2	10.2	28.3%	31.5%	17.8%	45.2%	6

	Median	Arithmetic mean	95% Confidence interval of the mean		In % of total staff[a]	In % of total staff (means)[b]	95% Confidence interval of the mean		Valid cases
			Lower[c]	Upper			Lower[c]	Upper	
Hungary									
Semmelweis University	6.5	7.5	-1.2	16.2	26.1%	35.0%	-1.3%	71.4%	4
Szent István University	3	3.3	0.9	5.6	27.7%	45.9%	-12.7%	104.5%	4
University of Debrecen	4	3.2	1.8	4.6	18.6%	22.9%	7.4%	38.3%	6
University of Pécs	3	2.8	2.2	3.4	21.2%	24.2%	10.3%	38.2%	5
University of Szeged	2.5	2.5	1.7	3.3	25.3%	25.9%	17.1%	34.6%	8
University of Veszprém	2	2.7	-2.5	7.8	25.8%	23.9%	-10.2%	58.1%	3
Italy									
Universita degli Studi di Firenze	2.5	3.0	0.7	5.3	26.1%	27.0%	11.3%	42.8%	4
Universita degli Studi di Milano	3	4.3	-1.4	10.1	12.1%	16.8%	-0.1%	33.7%	3
Universita degli Studi di Padova	2	2.0	-0.5	4.5	20.7%	22.1%	-6.9%	51.2%	3
Universita degli Studi di Pavia	2	1.7	-2.1	5.5	25.0%	22.6%	-30.9%	76.1%	3
Universita degli Studi di Trieste	2	3.0	1.2	4.8	26.3%	26.5%	13.8%	39.3%	5
Università di Bologna	2	2.4	1.0	3.8	25.5%	25.5%	14.9%	36.1%	5
University of Rome la Sapienza	2	2.3	0.9	3.8	19.4%	20.1%	9.4%	30.9%	3
Vita-Salute San Raffaele University	2.5	2.5	0.5	4.5	21.4%	18.7%	5.9%	31.5%	6
Norway									
Norwegian College of Veterinary Medicine	1.5	1.7	0.8	2.5	32.3%	33.1%	20.9%	45.2%	6
Norwegian University of Life Sciences	4	6.6	0.8	12.4	33.1%	33.6%	17.5%	49.7%	7
NTNU - Norwegian Univ. of S&T	4.5	4.5	2.0	7.0	31.8%	36.7%	24.9%	48.4%	6
University of Oslo	3	4.3	0.9	7.6	32.4%	28.6%	16.7%	40.6%	8
University of Bergen	2	2.5	0.8	4.2	24.7%	25.1%	14.2%	36.1%	8
Portugal									
Universidade de Coimbra	8	8.2	3.2	13.2	44.1%	44.9%	31.7%	58.2%	5
Universidade de Lisboa	3	5.4	1.1	9.7	29.7%	33.1%	15.2%	51.1%	8
Universidade do Minho	4	6.7	2.0	11.4	42.7%	39.7%	26.3%	53.2%	7
Universidade do Porto	4	4.6	0.2	9.0	25.3%	23.1%	5.8%	40.3%	5
Universidade Nova de Lisboa	5	4.7	2.7	6.6	36.8%	38.1%	26.6%	49.6%	9

	Median	Arithmetic mean	95% Confidence interval of the mean		In % of total staff[a]	In % of total staff (means)[b]	95% Confidence interval of the mean		Valid cases
			Lower[c]	Upper			Lower[c]	Upper	
Sweden									
Göteborg University	5.5	5.5	3.4	7.6	33.8%	33.9%	28.0%	39.8%	4
Karolinska Institutet - ett medicinskt universitet	5	4.3	-0.8	9.5	30.2%	34.2%	12.2%	56.1%	3
KTH Royal Institute of Technology Stockholm	5	5.6	-1.0	12.2	50.0%	37.5%	4.5%	70.5%	5
Stockholms Universitet	4	3.0	0.5	5.5	35.7%	35.1%	7.7%	62.6%	5
Umeå Universitet	3	2.6	1.2	4.0	41.9%	43.1%	30.6%	55.6%	5
Uppsala University	4.5	4.0	2.8	5.2	47.1%	47.1%	36.8%	57.5%	10
United Kingdom									
University of Cambridge	1	1.4	-0.7	3.5	15.2%	12.2%	-3.9%	28.2%	5
University of Dundee	1	2.0	-2.3	6.3	20.7%	19.6%	12.7%	26.6%	3
University of Edinburgh	1	2.0	0.2	3.8	32.3%	29.8%	18.1%	41.6%	5
University of Liverpool	2.5	2.3	0.7	3.8	27.3%	28.1%	13.4%	42.8%	4
University of Manchester	2	1.7	0.2	3.1	27.8%	29.6%	13.7%	45.6%	3
University of Newcastle upon Tyne	5.5	8.0	-5.6	21.6	34.0%	31.8%	21.9%	41.7%	4
University of Nottingham	2	3.3	-2.4	9.1	23.8%	22.5%	4.4%	40.7%	3
University of Oxford	5	5.3	0.8	9.9	34.0%	31.8%	14.5%	49.1%	6
University of St Andrews	4	6.5	-2.5	15.5	29.2%	34.0%	20.1%	47.8%	4
University of London	4	3.6	1.3	5.9	34.6%	35.1%	29.4%	40.8%	5
Medical Research Council	1	1.7	-1.2	4.5	26.3%	25.6%	-3.3%	54.5%	3
Total	**3**	**4.6**	**4.2**	**5.0**	**28.3%**	**30.1%**	**28.8%**	**31.5%**	**462**

a PhD students divided by total staff for all teams within a university.

b Arithmetic mean across all teams within a university for PhD students divided by total staff.

c The minimum possible value is 0 and negative values are impossible. They are shown to demonstrate the size of the variation.

Source: NetReAct survey

Doctoral students' countries of origin

Another set of variables for which we might expect differences between the universities in the sample are the countries of origin and last degree of the PhD students: though factors such as networks, individual qualifications, or team reputations should play a leading role in regard to the decisions on where PhD students study for the PhD, the university reputation might also be an element that makes it easier to attract students from abroad. Also, well-reputed universities might find it easier to recruit scholars from other countries who bring their personal networks and connection to their mother countries or previous countries of work with them. Hence, we expect that the more renowned universities are more international than less established organisations. We limit the analysis to the countries of origin of the PhD students, as the previous analysis at team level has shown that the other country-related variable, the country of last degree, adds only little further information.

The results shown in table 42 to some extent mirror what we already know from the country analysis on foreign PhD students (see table 22, p. 47). The most international teams were at the German universities of Freiburg, Tübingen and Heidelberg, the University of Milan, Bergen University in Norway, and nearly all Swedish and British universities (in particular Cambridge and Liverpool). At the Czech Academy of Sciences, the Université Paris-Sud, the Hungarian universities of Debrecen, Pécs, and Veszprém and the Italian Università di Bologna there were no doctoral students from other countries in the teams that responded to the survey. US American and Canadian students were particularly frequent at teams from the universities of Oxford and Dundee in the UK and the Université Montpellier II in France.

Table 42: Percentages of doctoral students by their country of origin and the university of the team

University of the team	Country of origin of the doctoral student					PhD students
	Own country	Other EU country	Other Europ. country outside EU	USA or Canada	Other country	
Czech Republic						
Charles University, Prague	90.5%	9.5%	0.0%	0.0%	0.0%	42
Masaryk University	81.3%	6.3%	0.0%	0.0%	12.5%	16
Czech Academy of Sci.	100.0%	0.0%	0.0%	0.0%	0.0%	15
Germany						
Albert-Ludwigs-Universität Freiburg	46.2%	7.7%	7.7%	0.0%	38.5%	13
Eberhard-Karls-Universität Tübingen	60.0%	6.7%	6.7%	0.0%	26.7%	15
Georg-August-Universität Göttingen	92.9%	0.0%	7.1%	0.0%	0.0%	14
Justus-Liebig Universität Giessen	87.5%	0.0%	0.0%	0.0%	12.5%	8
Ludwig-Maximilians-Universität München	73.7%	10.5%	0.0%	5.3%	10.5%	19

University of the team	Country of origin of the doctoral student					PhD students
	Own country	Other EU country	Other Europ. country outside EU	USA or Canada	Other country	
Ruprecht-Karls-Universität Heidelberg	58.3%	16.7%	4.2%	4.2%	16.7%	24
Spain						
Univ. Autónoma de Madrid	85.7%	0.0%	0.0%	0.0%	14.3%	7
Universidad de Sevilla	80.0%	0.0%	0.0%	0.0%	20.0%	15
Universitat de València	92.9%	0.0%	0.0%	0.0%	7.1%	14
University of La Laguna	73.3%	6.7%	0.0%	0.0%	20.0%	15
France						
Ecole Normale Supérieure	80.0%	20.0%	0.0%	0.0%	0.0%	15
Universite Montpellier II	83.3%	0.0%	0.0%	11.1%	5.6%	18
Université Paris-Sud XI	100.0%	0.0%	0.0%	0.0%	0.0%	11
Universite Paul Sabatier - Toulouse 4	78.3%	8.7%	0.0%	0.0%	13.0%	23
Universite Pierre et Marie Curie Paris 6	92.3%	0.0%	0.0%	0.0%	7.7%	13
CNRS	88.2%	0.0%	5.9%	0.0%	5.9%	17
Hungary						
Semmelweis University	87.5%	0.0%	12.5%	0.0%	0.0%	16
Szent István University	73.3%	0.0%	0.0%	0.0%	26.7%	15
University of Debrecen	100.0%	0.0%	0.0%	0.0%	0.0%	20
University of Pécs	100.0%	0.0%	0.0%	0.0%	0.0%	13
University of Szeged	85.2%	7.4%	7.4%	0.0%	0.0%	27
University of Veszprém	100.0%	0.0%	0.0%	0.0%	0.0%	8
Italy						
Univ. degli Studi di Firenze	88.9%	5.6%	0.0%	0.0%	5.6%	18
Univ. degli Studi di Milano	60.0%	40.0%	0.0%	0.0%	0.0%	10
Univ. degli Studi di Padova	88.9%	11.1%	0.0%	0.0%	0.0%	9
Univ. degli Studi di Trieste	84.0%	0.0%	8.0%	0.0%	8.0%	25
Università di Bologna	100.0%	0.0%	0.0%	0.0%	0.0%	13
Univ. of Rome la Sapienza	91.7%	0.0%	8.3%	0.0%	0.0%	12
Vita-Salute San Raffaele University	94.7%	5.3%	0.0%	0.0%	0.0%	19
Norway						
Norwegian College of Veterinary Medicine	82.4%	11.8%	0.0%	0.0%	5.9%	17
Norwegian University of Life Sciences	81.8%	3.0%	3.0%	0.0%	12.1%	33
NTNU - Norwegian Univ. of Science and Technology	73.7%	15.8%	5.3%	5.3%	0.0%	19
University of Oslo	90.9%	9.1%	0.0%	0.0%	0.0%	22
University of Bergen	66.7%	22.2%	0.0%	7.4%	3.7%	27
Portugal						
Universidade de Coimbra	85.7%	4.8%	0.0%	0.0%	9.5%	21
Universidade de Lisboa	93.1%	3.4%	0.0%	0.0%	3.4%	29
Universidade do Minho	88.5%	0.0%	3.8%	0.0%	7.7%	26
Universidade do Porto	94.4%	0.0%	0.0%	0.0%	5.6%	18

University of the team	Country of origin of the doctoral student					PhD students
	Own country	Other EU country	Other Europ. country outside EU	USA or Canada	Other country	
Univ. Nova de Lisboa	93.3%	3.3%	0.0%	0.0%	3.3%	30
Sweden						
Göteborg University	60.0%	25.0%	5.0%	0.0%	10.0%	20
Karolinska Institutet - ett medicinskt universitet	66.7%	8.3%	0.0%	0.0%	25.0%	12
KTH Royal Institute of Technology Stockholm	87.5%	12.5%	0.0%	0.0%	0.0%	16
Stockholms universitet	63.6%	4.5%	0.0%	0.0%	31.8%	22
Umeå universitet	56.3%	25.0%	0.0%	0.0%	18.8%	16
Uppsala university	52.1%	22.9%	6.3%	4.2%	14.6%	48
United Kingdom						
University of Cambridge	33.3%	11.1%	22.2%	0.0%	33.3%	9
University of Dundee	63.6%	0.0%	0.0%	18.2%	18.2%	11
University of Edinburgh	47.6%	47.6%	0.0%	0.0%	4.8%	21
University of Liverpool	36.4%	27.3%	0.0%	9.1%	27.3%	11
University of Manchester	90.9%	0.0%	0.0%	0.0%	9.1%	11
University of Newcastle upon Tyne	85.0%	5.0%	0.0%	0.0%	10.0%	20
University of Oxford	59.1%	13.6%	0.0%	13.6%	13.6%	22
University of St Andrews	57.1%	14.3%	7.1%	0.0%	21.4%	14
University of London	54.5%	18.2%	4.5%	0.0%	22.7%	22
Medical Research Council	50.0%	35.7%	0.0%	7.1%	7.1%	14
Total	**77.2%**	**9.0%**	**2.3%**	**1.4%**	**10.1%**	**1696**

Source: NetReAct survey.

In addition to the shares of PhD students for different country groups we also calculated the Shannon Diversity Index that measures the degree of diversity within the teams of a university (see p. 48 on the methodology). We calculated the arithmetic mean of the Shannon Diversity Index across all teams within a particular university, e.g. for the 10 teams of Charles University in Prague we get a mean diversity index of 0.21 c.f. table 43). As above, the confidence intervals are considerable, sometimes even going down to negative values at the lower bound (this is not possible, though, the minimum diversity value is 0 – no diversity). This indicates that the means do only have an indicative value and that they are significantly different to 0 from a statistical point of view only in few cases. We find large diversity indices for more or less the same universities that had large shares of foreign PhD students in the previous table.

Neither table 42 nor table 43 provides any clear evidence on the role of the university for recruiting doctoral students from abroad. The university values reflect to large extent the general country pattern. Only few universities differ significantly, such as the University of Milano in Italy, but we lack the evidence on whether this is due to their reputation.

Table 43: Shannon's Diversity Index for the countries of origin of the doctoral students by university of the team

University of the team	Arithmetic mean	95% Confidence interval of the mean		Teams
		lower bound[a]	upper bound	
Czech Republic				
Charles University, Prague	0.21	0.02	0.40	10
Masaryk University	0.40	-0.36	1.15	4
Czech Academy of Sciences	0.00	0.00	0.00	3
Germany				
Albert-Ludwigs-Univ. Freiburg	1.07	-0.17	2.30	3
Eberhard-Karls-Univ. Tübingen	0.84	0.10	1.57	3
Georg-August-Univ. Göttingen	0.17	-0.55	0.88	3
Justus-Liebig University Giessen	0.17	-0.55	0.88	3
Ludwig-Maximilians-Univ. München	0.60	-0.28	1.47	4
Ruprecht-Karls-Univ. Heidelberg	0.93	0.25	1.61	5
Spain				
Univ. Autónoma de Madrid	0.23	-0.76	1.23	3
Universidad de Sevilla	0.48	-0.70	1.66	3
Universitat de València	0.17	-0.38	0.72	4
University of La Laguna	0.61	-1.06	2.28	3
France				
Ecole Normale Supérieure	0.48	-0.70	1.66	3
Universite Montpellier II	0.34	-0.05	0.73	5
Université Paris-Sud (Paris XI)	0.00	0.00	0.00	4
Univ. Paul Sabatier - Toulouse 4	0.40	-0.28	1.08	5
Univ. Pierre et Marie Curie Paris 6	0.16	-0.35	0.67	4
CNRS	0.24	-0.17	0.65	5
Hungary				
Semmelweis University	0.32	-0.27	0.90	4
Szent István University	0.46	-0.54	1.46	4
University of Debrecen	0.00	0.00	0.00	5
University of Pécs	0.00	0.00	0.00	4
University of Szeged	0.32	-0.07	0.71	7
University of Veszprém	0.00	0.00	0.00	3
Italy				
Universita degli Studi di Firenze	0.25	-0.21	0.71	4
Universita degli Studi di Milano	0.61	0.36	0.86	3
Universita degli Studi di Padova	0.17	-0.55	0.88	3
Universita degli Studi di Trieste	0.32	-0.24	0.89	5
Università di Bologna	0.00	0.00	0.00	5
University of Rome la Sapienza	0.17	-0.55	0.88	3
Vita-Salute San Raffaele Univ.	0.10	-0.18	0.38	5
Norway				
Norwegian College of Veterinary Medicine	0.22	-0.35	0.79	6
Norwegian Univ. of Life Sci.	0.43	0.03	0.84	7

University of the team	Arithmetic mean	95% Confidence interval of the mean lower bound[a]	upper bound	Teams
NTNU - Norwegian University of Science and Technology	0.32	-0.24	0.89	5
University of Oslo	0.17	-0.10	0.44	7
University of Bergen	0.48	0.12	0.84	8
Portugal				
Universidade de Coimbra	0.29	-0.24	0.82	5
Universidade de Lisboa	0.13	-0.07	0.32	8
Universidade do Minho	0.23	-0.14	0.59	7
Universidade do Porto	0.10	-0.18	0.38	5
Universidade Nova de Lisboa	0.12	-0.16	0.40	8
Sweden				
Göteborg University	0.86	0.47	1.26	4
Karolinska Institutet - ett medicinskt universitet	0.61	-1.06	2.28	3
KTH Royal Institute of Technology Stockholm	0.24	-0.52	0.99	4
Stockholms universitet	0.60	-0.15	1.36	5
Umeå universitet	0.59	-0.23	1.41	5
Uppsala university	0.89	0.52	1.26	10
United Kingdom				
University of Cambridge	0.58	-0.64	1.79	4
University of Dundee	0.35	-1.16	1.86	3
University of Edinburgh	0.93	0.14	1.71	5
University of Liverpool	0.89	-1.02	2.80	3
University of Manchester	0.23	-0.76	1.23	3
Univ. of Newcastle upon Tyne	0.36	-0.36	1.09	4
University of Oxford	0.77	0.12	1.42	5
University of St Andrews	0.95	-0.15	2.05	3
University of London	0.85	0.57	1.12	5
Medical Research Council	1.10	0.47	1.72	3
Total	**0.41**	**0.36**	**0.45**	**422**

a The minimum possible value is 0 and negative values are impossible. They are shown to demonstrate the size of the variation.

Source: NetReAct survey.

Doctoral students' sources of funding

The funding of doctoral students was in all sample countries based on public sources issued either through the university or through other funding bodies (see pp. 50 ff.).

The university data reflect this finding, of course (see table 44). It is of particular interest to see on which universities the private funding concentrates. These are very few: in Germany only the university of Goettingen, in Spain Valencia, in France the University of Montpellier II and the CNRS, in Hungary Szent Istvan and Debrecen, in Italy Firenze, Trieste and Rome, the Norwegian University of Life Sciences, the Royal and Karolinska institutes in Stockholm, and last but not least Dundee, Liverpool and Edinburgh in the UK. Notably these universities are usually not the ones with many PhD students or a pronounced international composition of their PhDs students. It remains to be seen, whether they are in any way specific from a bibliometric point of view.

Table 44: Percentages of doctoral students by their source of funding and university of the team

University of the team	Source of funding of the doctoral students					PhD students
	Own university	Other public	Industry	Self-funded	Other funding	
Czech Republic						
Charles University, Prague	61.8%	38.2%	0.0%	0.0%	0.0%	34
Masaryk University	25.0%	33.3%	0.0%	41.7%	0.0%	12
Palacky University	85.7%	0.0%	0.0%	14.3%	0.0%	7
Czech Academy of Sci.	100.0%	0.0%	0.0%	0.0%	0.0%	15
Germany						
Albert-Ludwigs-Univ. Freiburg	7.7%	84.6%	0.0%	7.7%	0.0%	13
Eberhard-Karls-Univ. Tübingen	26.7%	33.3%	0.0%	6.7%	33.3%	15
Georg-August-Univ. Göttingen	28.6%	42.9%	7.1%	0.0%	21.4%	14
Justus-Liebig Univ. Giessen	12.5%	75.0%	0.0%	12.5%	0.0%	8
Ludwig-Maximilians-University München	0.0%	78.9%	0.0%	0.0%	21.1%	19
Ruprecht-Karls-Univ. Heidelberg	15.8%	73.7%	0.0%	5.3%	5.3%	19
Spain						
Universidad de Sevilla	9.1%	81.8%	0.0%	0.0%	9.1%	11
Universitat de València	0.0%	88.9%	11.1%	0.0%	0.0%	9
University of La Laguna	0.0%	100.0%	0.0%	0.0%	0.0%	12
France						
Ecole Normale Supérieure	33.3%	53.3%	0.0%	6.7%	6.7%	15
Universite Montpellier II	27.3%	50.0%	18.2%	4.5%	0.0%	22
Université Paris-Sud XI	45.5%	45.5%	0.0%	0.0%	9.1%	11
Univ. Paul Sabatier - Toulouse 4	18.2%	54.5%	4.5%	0.0%	22.7%	22
Universite Pierre et Marie Curie Paris 6	23.1%	53.8%	0.0%	7.7%	15.4%	13
CNRS	5.9%	70.6%	11.8%	0.0%	11.8%	17
Hungary						
Semmelweis University	84.6%	15.4%	0.0%	0.0%	0.0%	13
Szent István University	30.8%	23.1%	7.7%	23.1%	15.4%	13
University of Debrecen	75.0%	10.0%	15.0%	0.0%	0.0%	20
University of Pécs	46.2%	53.8%	0.0%	0.0%	0.0%	13
University of Szeged	57.7%	30.8%	0.0%	7.7%	3.8%	26
Italy						
Univ. degli Studi di Firenze	55.6%	27.8%	16.7%	0.0%	0.0%	18

Univ. degli Studi di Trieste	60.9%	30.4%	8.7%	0.0%	0.0%	23
Università di Bologna	72.7%	27.3%	0.0%	0.0%	0.0%	11
Univ. of Rome la Sapienza	83.3%	8.3%	8.3%	0.0%	0.0%	12
Vita-Salute San Raffaele Univ.	93.3%	6.7%	0.0%	0.0%	0.0%	15
Norway						
Norwegian College of Veterinary Medicine	20.0%	73.3%	0.0%	0.0%	6.7%	15
Norwegian Univ. of Life Sci.	13.3%	60.0%	20.0%	3.3%	3.3%	30
NTNU - Norwegian Univ. of Science and Technology	35.7%	50.0%	0.0%	0.0%	14.3%	14
University of Oslo	12.5%	83.3%	4.2%	0.0%	0.0%	24
University of Bergen	54.2%	45.8%	0.0%	0.0%	0.0%	24
Portugal						
Universidade de Coimbra	0.0%	76.2%	0.0%	23.8%	0.0%	21
Universidade de Lisboa	12.5%	75.0%	0.0%	12.5%	0.0%	24
Universidade do Minho	5.3%	94.7%	0.0%	0.0%	0.0%	19
Universidade do Porto	5.6%	83.3%	0.0%	0.0%	11.1%	18
Univ. Nova de Lisboa	0.0%	92.0%	0.0%	0.0%	8.0%	25
Sweden						
Göteborg University	31.6%	57.9%	0.0%	10.5%	0.0%	19
Karolinska Institutet - ett medicinskt universitet	40.0%	40.0%	10.0%	10.0%	0.0%	10
KTH Royal Institute of Technology Stockholm	0.0%	81.3%	18.8%	0.0%	0.0%	16
Stockholms universitet	27.3%	50.0%	0.0%	0.0%	22.7%	22
Umeå universitet	25.0%	68.8%	0.0%	6.3%	0.0%	16
Uppsala university	44.7%	48.9%	0.0%	0.0%	6.4%	47
United Kingdom						
University of Cambridge	28.6%	57.1%	0.0%	14.3%	0.0%	7
University of Dundee	0.0%	81.8%	9.1%	0.0%	9.1%	11
University of Edinburgh	23.8%	38.1%	9.5%	0.0%	28.6%	21
University of Liverpool	14.3%	71.4%	7.1%	0.0%	7.1%	14
University of Manchester	10.0%	70.0%	0.0%	10.0%	10.0%	10
Univ. of Newcastle upon Tyne	10.0%	80.0%	0.0%	5.0%	5.0%	20
University of Oxford	13.3%	73.3%	0.0%	0.0%	13.3%	15
University of St Andrews	0.0%	90.9%	0.0%	9.1%	0.0%	11
University of London	18.2%	36.4%	4.5%	27.3%	13.6%	22
Medical Research Council	85.7%	7.1%	0.0%	7.1%	0.0%	14
Total	**30.0%**	**54.4%**	**4.6%**	**4.2%**	**6.9%**	**1558**

Source: NetReAct survey.

Summary

The university level analysis used the information for roughly 60 universities for which more than three team leaders provided team information. Of course, it is daring to extrapolate the results for three teams to a population of more than 20 teams per university (see table 1, p. 17). However, we employed as much care as possible and looked at both, arithmetic means and standard errors.

As expected, the results reproduce in many ways the patterns found at team and country level. Due to large variances of the chosen indicators within universities it is rarely possible to identify valid and reliable differences between universities. Few universities seem to have a uniform strategy on the composition of research teams and the role of doctoral students in these. For the universities at Heidelberg, Coimbra, and Uppsala and the KTH Royal Institute of Technology Stockholm we found large and for the Milan and Cambridge universities small shares of PhD students in the life sciences teams.

The second step of the analysis looked at the country composition of the doctoral students in the universities. The most international teams were at the German universities of Freiburg, Tübingen and Heidelberg, the University of Milan in Italy, Bergen University in Norway, and nearly all Swedish and British universities (in particular Cambridge and Liverpool). The teams responding to the survey from the Czech Academy of Sciences, the Université Paris-Sud, the Hungarian universities of Debrecen, Pécs, and Veszprém and the Italian Università di Bologna did not have any doctoral students from other countries. US American and Canadian students were particularly frequent at teams from the universities of Oxford and Dundee in the UK and the Université Montpellier II in France. Comparing this with the previous result on team structure, we find that universities with few PhD students per team might be just as international as universities with many PhD students (e.g. Milan versus Heidelberg).

If we look at the source of funding of PhD students by university we do not see a clear pattern either. It is interesting to note that those universities who obtained funding for the PhD students from industry are usually not those with large shares of PhD students or with international teams. However, at the current point we do not know whether these are the successful outperformers or rather the underperformers when it comes to scientific publications and citations. This is something that will be investigated further in the work of WP 4.

6 Lessons learned and work do be done

6.1 Lessons learned in the survey

One of the purposes of the NetReAct project is to test the feasibility of the chosen approach to collect data on young researchers in science. The preparation and realisation of the survey taught us several lessons which should be remembered when a similar data collection is undertaken in other countries or for other disciplines. Most lessons learned are related to methodological questions, the contents of the questionnaire, or analytical results; those relating to the survey and in particular PhD students are briefly described in the following listing.

1. The time needed for assembling the research population of life sciences research teams in the ten NetReAct countries, drawing the sample, and obtaining usable address information on the sample teams from the World Wide Web was approximately twice as high as estimated in the project proposal. The identification and retrieval of research teams was only possible through time consuming searches of web pages in the university domain and manual copying-and-pasting of the relevant names and URLs. It was difficult in both large and small countries: the sheer size of the university-based life sciences in the UK, Germany, and France as well as varying institutional structures made it difficult to identify and collect all teams affiliated to universities. In some cases, in particular in Eastern and Southern Europe and in smaller and less known universities, the web pages were not very informative and did not always go down to the level of research teams. Moreover, in these little developed web presentations, links tended to be broken and the provided information was frequently outdated, incomplete or simply false. In these cases, it was very difficult to get a reliable picture of the research activities in the life sciences through the web.
2. In spite of these weaknesses, the approach proved to be successful. Nearly half of the teams included in the sample showed a measurable response to the survey and 26.4% of the teams entered the dataset with a usable questionnaire. Though the questionnaire was not translated into the mother languages and sent out in English, a negative effect on the response rates could not be detected. Moreover, a comparison between non-responding and responding teams in the dataset for a diverse set of structural variables – country, inlinks to the homepages, team size, numbers of PhD students and post-docs, gender of the team leader – did not provide evidence on any general bias. Some small restrictions for individual countries apply – e.g. teams with many post-docs are overrepresented in the dataset for Portugal and underrepresented for Sweden, teams with female leaders are overrepresented for Germany and underrepresented for Spain – but they do not provide any validity problem in the analysis. The dataset can be assumed to constitute a representative selection of the much larger research population.
3. A comparison of the staff data collected from the World Wide Web with the survey-based staff data indicated that the data from both sources is similar. Not only total staff numbers, but also the numbers of PhD students in both sources correlate: the

Pearson correlation coefficient between both data series is 0.68 and highly significant. According to the web the average number of PhD students per team was 5.0 and according to the survey it was 4.6 – though both data series do not refer to the same point in time. However, on the web information on doctoral students could only be found for 259 out of the 468 teams (55.3%) and the available information for this personnel group is usually very limited, mostly just the name and the position.

4. A particular concern prior to the realisation of the survey was whether it would be possible to obtain information for the beginning of the year 2003, more than 2 years before the survey (see NetReAct deliverable D1.1, p. 59). Merely 50 respondents (6.2% of the responses and 2.8% of the sample teams) stated that they did not have responsibility for a research team at the beginning of 2003. Hence, the reduction of the dataset according to this time lag between the realisation of the survey and the target-date is negligible overall; only in Norway the fluctuation between 2003 and 2005 seems to have been very high. Of course, it remains uncertain, whether all respondents really filled in the questionnaire for the target-date. It was frequently repeated in the questionnaire, but we have no way of verifying this.
5. The survey results also answer another question, namely whether it would be possible to obtain rather detailed data on individual PhD students and post-docs working in the teams (see D1.1, p. 70). The tables are not always filled out entirely and the respondents left open the questions they did not know for sure. But, for instance 426 team leaders provided information on the countries of origin of their PhD students, which is more than 90% of all teams in the dataset; and among the missing 42 teams for this variable are a number of teams which did not have any PhD students in 2003. In general, data on more than 1,500 PhD students working in the teams in 2003 and more than 1,400 students who left the teams since 2003 were provided by the team leaders.
6. These results also confirm the choice of the level of analysis, namely the lowest possible level (above individuals) of research teams. Not only were the team leaders able to fill in the questionnaires and provide the required answers, but the analysis of the results (so far on PhD students and graduates) produced a plausible and meaningful picture of life sciences teams. The team level seems to be superior to university level, too. Though we did not obtain any original data from university administrations and our university level analysis is merely based on limited data for a small set of universities, the aggregation clearly seems to conceal differences rather than reveal them. Moreover, the variations across teams affiliated to the same university are large making an identification of trends at this level nearly impossible.

6.2 Further lines of work

The deliverable provides a descriptive overview of the doctoral students in European life sciences research teams. It does not yet carry out any multivariate analyses with data on other team members like the team leader or post-docs which were also collected in the survey; bibliometric data on the publications of these teams and the citations of their publications; or webometric data on the hyperlinks pointing to the teams' web presentations. This kind of analysis is possible with the available data and it will constitute the major part of the work to be done in WP 4. Several issues will be discussed in this work-package:

1) In D1.1 (p. 40) three hypotheses were formulated on the role of doctoral students in the life sciences:

> H2.1: Research teams that realise a division of labour between junior and senior scientists have higher research productivity than teams that don't realise a division of labour.
>
> H2.2: Research teams with many PhD students do not have higher research productivity than teams with few PhD students.
>
> H2.3: The research productivity of teams fulfilling the implicit contract with PhD students is higher than the research productivity of teams that break it.

These hypotheses can be investigated by using the data on the overall composition and age structure of research teams (division of labour between junior and senior scientists), the share of PhD students and the professional trajectories of PhD graduates.

2) Moreover, the available data also permits to explore several further issues related to doctoral students:

- Are the structures of PhD students and post-docs related, for instance do teams with a heterogeneous set of doctoral students (in regard to country, discipline, gender) also have a heterogeneous set of post-docs?
- Are teams which are good at attracting doctoral students from abroad also good at attracting post-docs?
- What is the relationship between certain characteristics of the team leaders (country of birth, age, gender, discipline, recognition) and the doctoral students in their teams? What characteristics favour the attraction of PhD students from abroad?
- How are the characteristics of the doctoral students in a research team related to its productivity and collaborative relationships with other teams?
- How are the characteristics of the PhDs graduating from a research team related to its productivity and collaborative relationships with other teams?

3) Integrating the variables on doctoral students, post-docs, and collaborations typologies of teams can be constructed which then can be further analysed in regard to their research performance.

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Annex 1: Tables

Table A-1: Mean number of PhD students (from WWW) by response status and country[a]

Country	Non responses and unusable responses		Usable responses		Results of the statistical tests		
	Mean	S.E.	Mean	S.E.	ANOVA F-value	Levene-Test	Welch-Test
CZ	6.3	0.8	5.9	0.9	0.08	0.81	0.11
DE	5.5	0.4	5.4	0.6	0.05	0.11	0.05
ES	4.6	0.5	4.7	1.0	0.02	0.15	0.02
FR	5.0	0.5	4.9	0.9	0.02	0.16	0.02
HU	4.7	0.9	3.5	0.5	0.83	2.27	1.29
IT	3.0	0.4	3.6	0.7	0.62	0.50	0.59
NO	3.9	0.5	4.2	0.7	0.10	0.17	0.10
PT	3.9	0.4	5.3	0.9	2.32	4.72*	2.14
SE	5.9	0.5	5.6	0.8	0.12	0.20	0.12
UK	5.9	0.6	5.7	0.9	0.04	0.20	0.04
Total	**5.1**	**0.2**	**5.0**	**0.3**	**0.09**	**0.55**	**0.10**

a Based on data for 954 teams (53.8% of the sample).

F-Test on the congruence of means, Levene-Test on the homogeneity of variances, Welch-Test: robust test on the congruence of means for inhomogeneous variances.

Significance levels: ** p < 0.01, * p < 0.05, + p < 0.1.

Source: NetReAct (FHSO).

Table A-2: Mean number of post-docs (from WWW) by response status and country[a]

Country	Non responses and unusable responses		Usable responses		Results of the statistical tests		
	Mean	S.E.	Mean	S.E.	ANOVA F-value	Levene-Test	Welch-Test
CZ	2.0	0.4	1.1	0.5	1.77	0.03	1.77
DE	3.1	0.3	3.1	0.5	0.00	0.23	0.00
ES	1.8	0.2	2.0	0.4	0.15	0.85	0.21
FR	2.0	0.3	1.7	0.3	0.43	0.87	0.55
HU	3.1	0.4	2.4	0.6	0.96	0.15	0.84
IT	1.4	0.3	1.7	0.3	0.35	0.00	0.42
NO	2.8	0.5	2.8	0.5	0.00	0.42	0.00
PT	1.4	0.3	3.0	0.7	4.45*	3.39+	4.73*
SE	2.5	0.4	1.4	0.2	3.08+	8.50**	6.00*
UK	4.0	0.3	3.7	0.6	0.29	0.19	0.27
Total	**2.7**	**0.1**	**2.5**	**0.2**	**0.90**	**1.83**	**1.00**

a Based on data for 697 teams (39.3% of the sample).

F-Test on the congruence of means, Levene-Test on the homogeneity of variances, Welch-Test: robust test on the congruence of means for inhomogeneous variances.

Significance levels: ** p < 0.01, * p < 0.05, + p < 0.1.

Source: NetReAct (FHSO).

Table A-3: Usable responses to the survey by country

Country	Non responses and unusable responses		Usable responses		Total sample size
	N	in %	N	in %	N
CZ	89	74.8%	30	25.2%	119
DE	212	77.9%	60	22.1%	272
ES	127	77.4%	37	22.6%	164
FR	169	75.1%	56	24.9%	225
HU	74	68.5%	34	31.5%	108
IT	134	72.0%	52	28.0%	186
NO	84	69.4%	37	30.6%	121
PT	79	64.2%	44	35.8%	123
SE	108	72.5%	41	27.5%	149
UK	229	74.8%	77	25.2%	306
Total	**1,305**	**73.6%**	**468**	**26.4%**	**1,773**

Chi-square = 12.886, insignificant at $p < 0.1$

Source: NetReAct survey.

Table A-4: Academic disciplines based on K.U. Leuven – IRO Subject Classification

Code	Discipline	Code	Discipline
1	Z1 animal sciences	19	R5 physiology
2	Z2 aquatic sciences	20	I1 clinical medicine
3	Z3 microbiology	21	I2 experimental medicine
4	Z4 plant sciences	22	N1 neuroscience
5	Z5 pure and applied ecology	23	A agriculture, environment
6	Z6 veterinary sciences	24	N2 behaviour
7	B0 multidisciplinary biology	25	N3 psychology
8	B1 biochemistry/biophysics	26	C1 chemistry
9	B5 molecular biology	27	C2 chemical engineering
10	B2 cell biology	28	P physics
11	B3 genetics	29	G1 geosciences
12	B6 developmental biology	30	G2 space sciences
13	R1 anatomy and pathology	31	G3 hydrology
14	R2 biomaterials	32	G4 oceanography
15	R7 bioengineering	33	E1 engineering
16	R3 laboratory medicine	34	E2 computer science
17	R4 pharmacology	35	M mathematics
18	R6 toxicology	36	O others

Source: K.U. Leuven – IRO (NetReAct modifications).

Table A-5: Percentages of doctoral students by their gender and the age of the team

Team age	Gender of the doctoral student					
	Male PhD students		Female PhD students		All PhD students	
	N	In %	N	In %	N	In %
up to 5 years	112	49.8%	113	50.2%	225	100.0%
6-10 years	196	46.7%	224	53.3%	420	100.0%
11-15 years	169	47.2%	189	52.8%	358	100.0%
16-25 years	165	49.0%	172	51.0%	337	100.0%
more than 25 years	60	45.1%	73	54.9%	133	100.0%
Unknown	21	37.5%	35	62.5%	56	100.0%
Total	**723**	**47.3%**	**806**	**52.7%**	**1,529**	**100.0%**

Source: NetReAct survey.

Table A-6: Percentages of doctoral students by their discipline of doctoral research and the age of the team

Age of the team	Discipline of the doctoral student					All PhD students
	Biology	Bio-sciences	Bio-medicine	Neuro-sciences	Other disciplines	
up to 5 years	30.7%	41.7%	6.1%	4.4%	17.1%	228
6-10 years	23.9%	49.5%	6.4%	5.9%	14.2%	422
11-15 years	24.3%	50.0%	8.3%	5.8%	11.6%	362
16-25 years	21.3%	47.0%	8.3%	8.9%	14.5%	338
more than 25 years	37.9%	36.4%	6.1%	6.1%	13.6%	132
Unknown	40.4%	33.3%	5.3%	0.0%	21.1%	57
Total	**26.3%**	**46.2%**	**7.1%**	**6.1%**	**14.3%**	**1,539**

Source: NetReAct survey.

Table A-7: Percentages of doctoral students by their discipline of doctoral research and the size of the team

Size of the team (no. of total staff)	Discipline of the doctoral student					All PhD students
	Biology	Bio-sciences	Bio-medicine	Neuro-sciences	Other disciplines	
less than 10	26.6%	53.0%	4.3%	4.1%	12.1%	489
10 to 19	23.3%	46.5%	8.2%	6.5%	15.5%	645
20 to 29	26.5%	39.3%	6.6%	7.1%	20.4%	211
30 to 49	42.7%	30.6%	8.1%	11.3%	7.3%	124
50 or more	26.2%	40.5%	14.3%	3.6%	15.5%	84
Total	**26.5%**	**46.0%**	**7.1%**	**6.1%**	**14.4%**	**1,553**

Source: NetReAct survey.

Table A-8: Percentages of doctoral students by their country of last degree and the country of the team

Country of the team	Country of last degree of the doctoral student					
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	All PhD students
CZ	90.4%	7.7%	0.0%	0.0%	1.9%	104
DE	73.1%	8.5%	4.0%	1.8%	12.6%	223
ES	81.1%	5.6%	0.7%	0.0%	12.6%	143
FR	87.6%	4.1%	0.5%	1.5%	6.2%	194
HU	91.1%	1.8%	5.4%	0.0%	1.8%	112
IT	91.3%	4.1%	1.7%	0.6%	2.3%	172
NO	80.8%	11.2%	0.8%	2.4%	4.8%	125
PT	84.0%	8.3%	1.4%	1.4%	4.9%	144
SE	66.0%	16.7%	2.5%	1.2%	13.6%	162
UK	69.0%	10.8%	1.7%	5.1%	13.1%	297
Total	**79.7%**	**8.2%**	**1.9%**	**1.8%**	**8.4%**	**1676**

Source: NetReAct survey.

Table A-9: Shannon's Diversity Index for the countries of last degree of the doctoral students by country of the team

Country	Arithmetic mean	95% Confidence interval of the mean		No. of teams
		lower bound	upper bound	
CZ	0.20	0.08	0.32	26
DE	0.54	0.42	0.66	53
ES	0.37	0.21	0.53	34
FR	0.24	0.14	0.35	49
HU	0.18	0.03	0.32	30
IT	0.14	0.06	0.22	47
NO	0.33	0.19	0.47	35
PT	0.29	0.15	0.43	37
SE	0.64	0.48	0.80	37
UK	0.60	0.49	0.70	70
Total	**0.38**	**0.34**	**0.42**	**418**

F-Test on the congruence of means: F-value 8.865, $p<0.01$
Levene-Test on the homogeneity of variances: 3.567, $p<0.01$
Robust tests on the congruence of means: Welch-Test: 9.422, $p<0.01$, Brown-Forsythe-Test: 9.060, $p<0.01$

Source: NetReAct survey.

Table A-10: Percentages of doctoral students by their country of last degree and the main discipline of the team

Main discipline of the team	Country of last degree of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
Biology	78.2%	7.3%	1.5%	2.7%	10.3%	262
Biosciences	80.9%	8.6%	2.4%	2.1%	6.1%	676
Biomedicine	80.0%	5.5%	1.8%	3.6%	9.1%	55
Neurosciences	84.3%	5.7%	1.4%	2.9%	5.7%	70
Others	81.7%	8.7%	1.6%	1.6%	6.3%	126
Multiple disciplines	76.8%	8.9%	1.6%	0.8%	11.7%	384
Total	**79.7%**	**8.2%**	**1.9%**	**1.9%**	**8.3%**	**1,573**

Source: NetReAct survey.

Table A-11: Percentages of doctoral students by their country of last degree and the age of the team

Age of the team	Country of last degree of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
up to 5 years	81.6%	6.9%	3.3%	2.0%	6.1%	245
6-10 years	82.0%	6.7%	1.6%	1.6%	8.1%	445
11-15 years	81.2%	9.3%	2.3%	1.0%	6.2%	389
16-25 years	74.7%	9.2%	1.3%	3.2%	11.6%	371
more than 25 years	73.0%	10.6%	1.4%	0.7%	13.5%	141
Unknown	84.2%	8.8%	1.8%	1.8%	3.5%	57
Total	**79.4%**	**8.3%**	**1.9%**	**1.8%**	**8.4%**	**1,648**

Source: NetReAct survey.

Table A-12: Percentages of doctoral students by their country of origin and the size of the team

Size of the team (no. of total staff)	Country of origin of the doctoral student					All PhD students
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
less than 10	75.3%	9.8%	2.6%	2.0%	10.3%	543
10 to 19	78.9%	8.0%	2.3%	1.2%	9.6%	687
20 to 29	76.3%	9.9%	1.3%	0.4%	12.1%	232
30 to 49	74.3%	7.1%	2.9%	2.1%	13.6%	140
50 or more	81.1%	12.2%	1.1%	1.1%	4.4%	90
Total	**77.1%**	**9.0%**	**2.2%**	**1.4%**	**10.2%**	**1,692**

Source: NetReAct survey.

Table A-13: Percentages of doctoral students by their country of last degree and the size of the team

Size of the team	Country of last degree of the doctoral student	All PhD

(no. of total staff)	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	students
less than 10	77.6%	8.1%	2.6%	2.3%	9.2%	531
10 to 19	81.7%	7.2%	1.8%	1.5%	7.8%	678
20 to 29	77.8%	11.1%	0.9%	0.4%	9.8%	234
30 to 49	78.9%	7.5%	1.5%	3.0%	9.0%	133
50 or more	84.9%	8.1%	2.3%	1.2%	3.5%	86
Total	**79.8%**	**8.1%**	**1.9%**	**1.7%**	**8.4%**	**1,662**

Source: NetReAct survey.

Table A-14: Percentages of doctoral students by their duration of funding and main discipline of the team

Main discipline of the team	Duration of funding of the doctoral students			All PhD students
	0-1 years	2-3 years	> 3 years	
Biology	0.8%	37.4%	61.7%	243
Biosciences	2.5%	32.9%	64.6%	642
Biomedicine	2.1%	42.6%	55.3%	47
Neurosciences	0.0%	62.3%	37.7%	53
Others	3.3%	41.0%	55.7%	122
Multiple disciplines	2.2%	31.0%	66.8%	368
Total	**2.1%**	**35.2%**	**62.7%**	**1,475**

Source: NetReAct survey.

Table A-15: Percentages of doctoral students by their duration of funding and age of the team

Age of the team	Duration of funding of the doctoral students			All PhD students
	0-1 years	2-3 years	> 3 years	
up to 5 years	0.9%	40.1%	59.0%	217
6-10 years	3.9%	33.0%	63.1%	409
11-15 years	2.3%	32.8%	64.9%	348
16-25 years	1.5%	31.0%	67.5%	335
more than 25 years	1.6%	40.3%	58.1%	129
Unknown	1.8%	45.6%	52.6%	57
Total	**2.3%**	**34.6%**	**63.1%**	**1,495**

Source: NetReAct survey.

Table A-16: Percentages of doctoral students by their duration of funding and size of the team

Total staff of the team	Duration of funding of the doctoral students			All PhD students
	0-1 years	2-3 years	> 3 years	
less than 10	2.5%	35.7%	61.8%	474
10 to 19	3.0%	34.6%	62.4%	625
20 to 29	1.0%	28.2%	70.8%	209
30 to 49	0.8%	47.9%	51.3%	119
50 or more	0.0%	41.5%	58.5%	82
Total	**2.3%**	**35.5%**	**62.3%**	**1,509**

Source: NetReAct survey.

Table A-17: Percentages of PhD graduates by their new activity and the age of the team

Age of the team	New activity of the PhD graduates					All PhD graduates
	Post-doc or temporary position	Faculty or other perma-nent position	Other R&D activity	Other employ ment	No employ-ment	
up to 5 years	50.3%	15.8%	15.2%	15.2%	3.6%	165
6-10 years	51.0%	16.0%	15.4%	15.2%	2.5%	363
11-15 years	51.0%	17.5%	15.3%	13.4%	2.8%	359
16-25 years	42.3%	17.6%	18.5%	18.2%	3.6%	336
more than 25 years	47.8%	19.9%	12.5%	15.4%	4.4%	136
Unknown	36.4%	33.3%	9.1%	21.2%	0.0%	33
Total	**48.1%**	**17.5%**	**15.7%**	**15.6%**	**3.1%**	**1,392**

Source: NetReAct survey.

Table A-18: Percentages of PhD graduates by their new activity and the size of the team

Size of the team	New activity of the PhD graduates					All PhD graduates
	Post-doc or temporary position	Faculty or other perma-	Other R&D	Other employ	No employ-	

		nent position	activity	ment	ment	
less than 10	50.1%	16.4%	14.1%	16.4%	3.0%	403
10 to 19	49.6%	15.7%	16.4%	15.0%	3.2%	585
20 to 29	42.9%	18.9%	16.5%	18.4%	3.3%	212
30 to 49	44.0%	24.8%	12.8%	15.2%	3.2%	125
50 or more	44.0%	23.8%	16.7%	14.3%	1.2%	84
Total	**47.9%**	**17.7%**	**15.5%**	**15.9%**	**3.1%**	**1,409**

Source: NetReAct survey.

Table A-19: Percentages of PhD graduates by their new organisation and the main discipline of the team

Main discipline of the team	New organisation of the PhD graduates			All PhD graduates
	University	Other public organisation	Private sector	
Biology	53.2%	28.4%	18.4%	201
Biosciences	58.2%	21.6%	20.2%	565
Biomedicine	64.9%	13.5%	21.6%	37
Neurosciences	63.9%	16.4%	19.7%	61
Others	45.9%	36.9%	17.1%	111
Multiple disciplines	59.6%	19.6%	20.8%	322
Total	**57.2%**	**23.0%**	**19.8%**	**1,297**

Source: NetReAct survey.

Table A-20: Percentages of PhD graduates by their new organisation and the age of the team

Age of the team	New organisation of the PhD graduates			All PhD graduates
	University	Other public organisation	Private sector	
up to 5 years	61.1%	22.3%	16.6%	157
6-10 years	58.5%	22.1%	19.4%	340
11-15 years	59.0%	23.8%	17.2%	344
16-25 years	53.1%	25.5%	21.4%	318
more than 25 years	54.3%	20.2%	25.6%	129
Unknown	63.6%	15.2%	21.2%	33
Total	**57.4%**	**23.0%**	**19.6%**	**1,321**

Source: NetReAct survey.

Table A-21: Percentages of PhD graduates by their new organisation and the size of the team

Size of the team	New organisation of the PhD graduates			All PhD graduates
	University	Other public organisation	Private sector	
less than 10	59.0%	21.9%	19.1%	388
10 to 19	57.5%	23.1%	19.4%	546

20 to 29	54.9%	25.5%	19.6%	204
30 to 49	58.7%	21.5%	19.8%	121
50 or more	49.4%	22.8%	27.8%	79
Total	**57.2%**	**22.9%**	**19.9%**	**1,338**

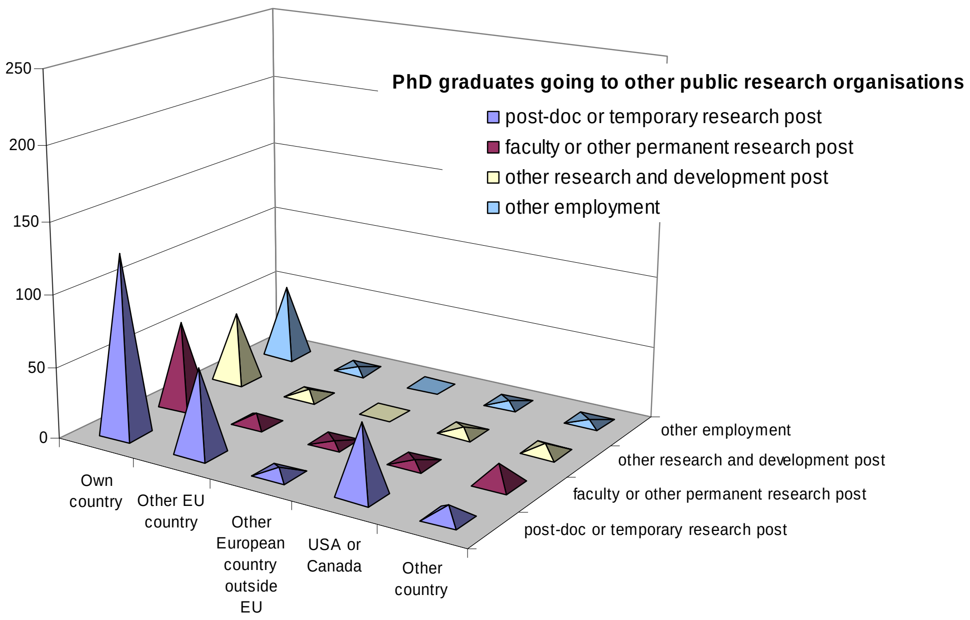
Source: NetReAct survey.

Table A-22: Percentages of PhD graduates by new country of work and the size of the team

Size of the team (no. of total staff)	Country of destination of the PhD graduates					All PhD graduates
	Own country	Other EU country	Other European country outside EU	USA or Canada	Other country	
less than 10	63.3%	11.7%	2.8%	13.3%	8.9%	436
10 to 19	68.4%	12.7%	1.0%	10.7%	7.2%	598
20 to 29	68.6%	12.6%	1.3%	9.9%	7.6%	223
30 to 49	66.9%	13.5%	0.8%	9.8%	9.0%	133
50 or more	75.6%	7.8%	0.0%	11.1%	5.6%	90
Total	**67.2%**	**12.2%**	**1.5%**	**11.3%**	**7.8%**	**1,480**

Source: NetReAct survey.

Figure A-1: PhD graduates by their new organisation of work, activity and destination country



Source: NetReAct survey.

Table A-23: Factors determining the attractiveness of groups for PhD students by country of the team

Country of the team	Scientific reputation	Quality of PhD education	Industry contacts	Suitable candidates	Outside recommendations	Generally available information	Targeted information	Other factors
					Median			
CZ	2	2	5	3	3	4	4	5
DE	2	2	4	2	3	3	4	5
ES	2	3	4	3	3	3	4	5
FR	1	2	4	2	3	3	4	5
HU	2	2	4	2	3	4	4	5
IT	2	2	4	3	3	4	4	5
NO	2	3	4	3	3	3.5	4	5
PT	2	2	4	3	3	3	4	5
SE	2	2	4	3	3	3	4	5
UK	1	2	4	3	3	2	4	5
Total	**2**	**2**	**4**	**3**	**3**	**3**	**4**	**5**
Chi-square[a]	**32.850****	**27.266****	**11.906**	**24.279****	**29.678****	**56.833****	**9.295**	**9.315**
					Arithmetic mean			
CZ	2.3	2.4	4.3	2.8	3.0	3.6	4.0	4.4
DE	1.9	2.5	4.2	2.5	2.6	2.9	4.0	4.7
ES	2.0	2.5	3.9	2.9	2.6	3.3	4.0	4.7
FR	1.6	2.1	3.9	2.4	2.5	3.0	3.7	4.4
HU	1.9	2.2	3.9	2.4	3.0	3.8	3.6	4.3
IT	1.8	2.3	4.0	2.8	3.2	3.4	3.8	4.6
NO	2.2	2.9	4.0	2.6	3.3	3.3	4.2	4.6
PT	1.7	2.3	4.1	2.9	2.7	3.3	3.8	4.5
SE	1.8	2.2	4.0	2.8	3.0	3.0	4.1	4.4
UK	1.6	2.2	3.9	3.1	2.6	2.5	3.8	4.7
Total	**1.8**	**2.3**	**4.0**	**2.7**	**2.8**	**3.1**	**3.9**	**4.6**

a Results from Kruskal-Wallis Tests; significance levels ** < 0.01, * < 0.05, + < 0.1.

Source: NetReAct (FHSO).

Table A-24: Desired characteristics of applicants for PhD studentships by country of the team

Country of the team	Publications	Grades	Teaching experience	Right discipline	Specific knowledge	Work experience	Reputation of previous aff.	Recommen-dations	Worked with the group	Highly motivated	Fits socially
					Median						
CZ	3	3	4.5	3	3	3	3	3	3	2	3
DE	3	2	4	2	2	3	2	2	3	1	2
ES	3	2	4	2	3	3	3	2	3	2	2
FR	3	3	4	2	3	3	2	2	4	1	2
HU	3	3	4	2	3	3	3	2.5	2.5	1.5	2
IT	3	3	4	2	2	3	2	3	3	2	2
NO	3.5	2	4	2	3	3	3	3	4	2	3
PT	3	2	4	3	2	3	2	2	3	1	2
SE	4	3	4	2	3	3	2	2	3	1	2
UK	4	2	5	2	3	3	2	2	4	1	2
Total	**3**	**2**	**4**	**2**	**3**	**3**	**2**	**2**	**3**	**1**	**2**
Chi-square[a]	**38.827****	**36.388****	**42.185****	**8.956**	**9.359**	**21.717***	**9.576**	**32.231****	**60.633****	**20.382***	**34.200****
					Arithmetic mean						
CZ	2.9	2.8	4.3	2.7	2.9	3.2	2.6	2.6	2.7	1.6	2.6
DE	3.1	2.3	3.8	2.4	2.5	2.8	2.4	2.5	3.3	1.4	1.9
ES	3.4	2.4	3.9	2.3	2.6	2.9	2.7	2.6	3.2	1.7	2.4
FR	3.4	2.6	4.2	2.3	2.6	3.3	2.6	2.2	3.5	1.5	2.0
HU	3.1	2.6	3.9	2.4	2.6	3.1	2.7	2.6	2.6	1.6	2.4
IT	3.1	2.7	4.1	2.4	2.4	2.7	2.6	3.1	3.1	1.9	2.5
NO	3.3	2.2	4.1	2.5	2.6	3.0	2.8	2.7	3.7	1.8	2.5
PT	3.3	2.1	4.3	2.6	2.5	2.9	2.4	2.5	3.0	1.4	2.1
SE	3.6	2.6	4.1	2.2	2.6	3.0	2.4	2.1	2.6	1.4	2.0
UK	3.9	2.1	4.5	2.4	2.8	3.2	2.4	2.4	3.8	1.4	2.4
Total	**3.4**	**2.4**	**4.2**	**2.4**	**2.6**	**3.0**	**2.5**	**2.5**	**3.2**	**1.5**	**2.2**

a Results from Kruskal-Wallis Tests; significance levels ** < 0.01, * < 0.05, + < 0.1.

Source: NetReAct (FHSO).

Annex 2: Questionnaire (word for print version)

NetReAct

European Study of Research Cooperation

in the Life Sciences

Questionnaire
for
Heads of Life Science Research Teams

June 2005

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre
Institute for Prospective Technological Studies

University of Applied Sciences Solothurn Northwestern Switzerland
Engineering - Business - Social Sciences

empirica
Gesellschaft für Kommunikations- und Technologieforschung mbH

UNIVERSITY OF WOLVERHAMPTON

Introduction

The **NetReAct** project has been commissioned by the Joint Research Centre of the European Union in Seville to explore the impact of the composition of European Life Science research teams and research collaboration on research output, with a focus on research structure and in particular the role of doctoral students and postdoctoral researchers. For reasons of bibliometric and citation analysis, the **focus** of the study is **on the year 2003 and earlier.**

In answering this questionnaire for your research group you may wish to delegate answering questions to colleagues or staff. **Questions which can be passed on** for someone else to respond to **are marked for your convenience**. The *other respondents* can send their part of the questionnaire back to the study team at netreact@empirica.com directly, or you may collect them and send them to us together, as you wish. Please **answer question 1** (name of your group) **in all copies** of the questionnaire to ensure we can merge these.

How to complete the questionnaire: This questionnaire is designed to be completed **in a printed copy**. Please use **code lists A to G at the end of the questionnaire** when use of a code list is specified in a question. If you have any **comments** on questions, please provide these **at the end** of the questionnaire. Please **send** us the filled-in questionnaire **by fax** (+49-228-98530-12, Keyword: Netreact) or **email** (netreact@empirica.com) us the **scanned questionnaire**.

Research group definition

1 Which research group do (or did) you have responsibility for and which existed at the beginning of 2003?

For the purposes of this study a ***research group*** **is** 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**.

If you have responsibility for several research groups, please choose the one that you know best and that was active at the beginning of 2003.

Local name of your (chosen) research group: ________________________

NOTE: The following **questions refer to this group**, that you led at the beginning of 2003 and maybe still lead, **as *your group*.**

(☐) I did not have responsibility for any research group at the beginning of 2003

If you have not named a research group please send the questionnaire back without answering further questions!

2 To which university or organisation was your group affiliated at the beginning of 2003?

NOTE: Multiple answers are possible if there was more than one affiliation

(☐) Same university as today

(☐) Different university, ________________________ (name) in ________________________ (country)

(☐) Non-university public research organisation, ________________________ (name) in ________________________ (country)

(☐) Private company

(☐) Others

3 In what year did your group start to do research?

Year research began:____________ (☐) don't know

NOTE: The remainder of the questions in this section, Nos 4 to 7 , can be delegated at your convenience.

4 What were the most important fields covered by PhD research in your group at the beginning of 2003?

NOTE: Please enter at least one field. Please use **Code List A** (see end of questionnaire).

Doctoral field 1	Doctoral field 2	Doctoral field 3

5 How large was your group at the beginning of 2003?

Please provide the number of persons in each category, include yourself, count each person only once, and **include those on leave for less than 6 months** and guests or visitors **staying more than 6 months**.

	Principal investigators (e.g. team leaders, professors)
	Post-doctoral researchers (usually PhD under 5 years ago i.e. 1998 or after)
	Other researchers (with PhD before 1998)
	PhD students
	Other research students (e.g. Masters students)
	Technical Staff (posts not requiring PhD or equivalent)
	Other staff (e.g. administrative)

6 Has the overall size of your group changed since the beginning of 2003?

Note: Please use **Code List G** (see end of questionnaire).

Since the beginning of 2003 the research group has ______________________

7 How many short term visiting researchers (1 week to 6 months) did your group have per year on average?

_______Number of short term visitors (☐) No short term visitors

Attracting new research personnel

8 What factors help your group attract the right type and optimal number of applicants for PhD studentships and post-doctoral research posts?

If this has changed significantly in recent years, please try to answer for the period 2000 - 2002 inclusive.

Note: Please use **Code List B** (see end of questionnaire).

Factors	PhD studentship	Post-doctoral research posts
Our scientific reputation.		same as PhD students, or (enter code) _________
The quality of our PhD education and/or post-doctoral training.		same as PhD students, or (enter code) _________
Our industry contacts.		same as PhD students, or (enter code) __________
Suitable candidates qualifying here.		same as PhD students, or (enter code) __________

Recommendations to candidates elsewhere by researchers working elsewhere who know us.		same as PhD students, or (enter code) ___________
Broadly accessible information, e.g. placed on our web-site, in newsletters, job agencies, journals, newspapers etc.		same as PhD students, or (enter code) ___________
Targeted information sent to selected schools, other organisations or individuals.		same as PhD students, or (enter code) ___________
Other important factors, please list: ______________________		same as PhD students, or (enter code) ___________

9 How important is it for the productivity of your group to increase the proportion of PhD students and post-doctoral researchers from your own organisation (university) or from specific schools, universities or other organisations located elsewhere in the world? How important is it to increase the proportion from ...

(If this has changed significantly in recent years, please try to answer for the period 2000 - 2002 inclusive.)

Note: Please use **Code List B** (see end of questionnaire).

	… your own organisation (university)
	… other schools, universities and other organisations in your **own country**
	… schools, universities and other organisations in **other EU countries**
	… schools, universities and other organisations in **Japan**
	… schools, universities and other organisations in the **USA**
	… schools, universities and other organisations in **other non-EU countries**

10 What characteristics of applicants for PhD studentships and post-doctoral research posts are most important for acceptance into your group?

(If this has changed significantly in recent years, please try to answer for the period 2000 - 2002 inclusive)

Note: Please use **Code List B** (see end of questionnaire).

Characteristics	PhD studentships	Post-doctoral research posts
Large number or high quality of publications		same as PhD students, or (enter code) ___________
High quality of grades		same as PhD students, or (enter code) ___________
Extensive teaching experience		same as PhD students, or (enter code) ___________
Appropriate discipline		same as PhD students, or (enter code) ___________
Specific knowledge (theories, techniques etc. within a discipline) related to the post / studentship		same as PhD students, or (enter code) ___________
Having already worked in an area related to the post / studentship		same as PhD students, or (enter code) ___________
Good reputation of previous affiliations (degree-awarding university, department or professor)		same as PhD students, or (enter code) ___________
Recommended by a well-regarded colleague		same as PhD students, or (enter code) ___________
Has worked with your group prior to application		same as PhD students, or (enter code) ___________

Highly motivated for the research topic		same as PhD students, or (enter code) ___________
Expected to fit well into the team socially		same as PhD students, or (enter code) ___________
Other important characteristic: ________________________		same as PhD students, or (enter code) ___________

Doctoral students

NOTE: Questions Nos 11 and 12 in this section can be delegated to another respondent at your convenience.

11 Where did your PhD students come from? Please provide information on the 5 PhD students who joined the group most recently but before 2003.

Note: Please use **Code List A, C and D** (see end of questionnaire).

PhD student No.	*Name / alias (not required)*	*Age (approx.) / Origin*		*Gender*	*Country of last degree*	*Main field of doctoral research (Code A)*	*Funding ("own" means funding decisions taken in your university / organisation)*	
		Age	Country				main source *(Code C)*	duration *(Code D)*
1				☐ F ☐ M				
2				☐ F ☐ M				
3				☐ F ☐ M				
4				☐ F ☐ M				
5				☐ F ☐ M				

12 What activities do your PhD students take up when they leave? For the five PhD students who most recently left (with or without a PhD) please provide type and location of activity.

Note: Please use **Code List E and F** (see end of questionnaire).

PhD student No.	*Name / alias* *(not required)*	*Country*	*Activity (Code E)*	*Organisation (Code F)*
1				
2				
3				
4				
5				

13 Was your team associated with a graduate school in the years 2001-2003?

☐ Yes

☐ No

Post-doctoral researchers

NOTE: Questions Nos 14 and 15 in this section can be delegated to another respondent at your convenience.

14 Where did your post-doctoral researchers come from? Please provide information on the 5 post-doctoral researchers (usually PHD 1998 or after) who joined the group most recently but before 2003.

Note: Please use **Code List A, C and D** (see end of questionnaire).

Post-doc No.	*Name / alias (not required)*	*Age (approx.) / Origin*		*Gender*	*PhD: University and country*	*Main field of doctoral research (Code A)*	*Year of PhD*	*Funding*		*Work experience abroad?*
		Age	*Country*					*Main source (Code C)*	*(planned) duration (Code D)*	
1				☐ F ☐ M				--------------	--------------	☐ Y ☐ N
2				☐ F ☐ M				--------------	--------------	☐ Y ☐ N
3				☐ F ☐ M				--------------	--------------	☐ Y ☐ N
4				☐ F ☐ M				--------------	--------------	☐ Y ☐ N
5				☐ F ☐ M				--------------	--------------	☐ Y ☐ N

15 What activities do your postdoctoral researchers take up when they leave? For the 5 who <u>most recently left</u> please provide type and location of activity.

Note: Please use **Code List E and F** (see end of questionnaire).

Post-doc No.	*Name / alias (not required)*	*Country*	*Activity (Code E)*	*Organisation (Code F)*
1				
2				
3				
4				
5				

Profile of head of the research group

Please provide some information on yourself as head of the research group.

16 **Your country of birth:**____________________.

17 **Your age category:**___________________.

18 From which university did you obtain your PhD? University: ___________________, Country:_____________.

19 Please indicate the main field your PhD research covered.

Note: Please use **Code List A** (see end of questionnaire).

Doctoral research field:	

20 When did you first take on the leadership of a research team? Year:____________.

21 **Since 2000, has your work been recognised in any of the following ways? Have you …** (Multiple answers possible)

(☐) won a scientific award

(☐) invited to serve on a major professional committee

(☐) invited to serve on editorial board of a scientific journal

(☐) organised an international conference

(☐) invited to serve on a national or international advisory committee

Other principal investigators (professors and other research staff)

To complement the information on PhD students, post-doctoral researchers (usually PhD 1998 and after), and yourself as head of research, we now address the other professors and researchers in your group, if any.

NOTE: All questions in this section can be delegated to another respondent at your convenience.

22 Where did the others professors and researchers obtain their PhD qualification?

Number with PhD…	Number
…from **own country**:	
... from other **EU country**:	

... from **Japan**:	
... from **USA**:	
... from **other non-EU country**:	
don't know	

Research collaboration

23 How many other research groups did your group collaborate with in 2003?

For the purposes of this study, **research collaboration** is when members of your group work with another group on a common topic and with the **intention of publishing results jointly** with at least one member of the other group. We do not include as collaboration agreements with no associated joint research activity, or cases where one group just provides equipment, services or consultancy to another without the intention of joint publication.

Number of other groups with which your group collaborated …

- …within your main field:_______________.
- …interdisciplinary (the collaborators mainly work in a different field than your team):_______________.

24 What are the most important aspects of collaboration for your group?

(If this has changed significantly in recent years, please try to answer for the period 2000 - 2002 inclusive)
Note: Please use **Code List B** (see end of questionnaire).

How important is it for the productivity of your group that collaboration…

	provide access to other scientists' expertise and knowledge.
	pool research capacity for solving large and complex problems
	realise a division of labour or facilitate further specialisation of your group
	enable learning of a new method or the use of a new instrument
	increase prestige through working with renowned colleagues
	be a pleasurable activity
	help maintain pre-established relationships
	give access to equipment, resources, data or other evidence
	fulfil requirements of funding programmes
	facilitate or enhance the education of students or junior scientists
	other aspects

Comments: ________________________

25 How has the collaboration activity of the group changed since 2003?

Please enter the appropriate code from the **Code list G** (see end of questionnaire): ___________

26 How many publications have been authored by members of your group?

NOTE: This question **can be delegated** to another respondent at your convenience.

In this study we are to further characterise research collaboration patterns by analysing authorship and co-authorship in publications. We have access to publication databases, but **require the names of authors** to link publications with your group. **A list of publications instead of authors would help** improve quality and reduce our analytic task. Please therefore supply a list of authors, or preferably a list of publications, spanning the period **2001 to 2003**, in the manner most convenient to you. Please indicate if

(☐) a list of publications/authors is to be found in the field below.

(☐) a list of publications/authors is attached to your reply (e.g. as a text file or scan).

(☐) a list of publications/authors has been faxed to empirica on +49 228 98530-12 - keyword "NetReAct".

List of publications or authors (a list can be "copy-pasted" into this field):

____

Questions on the questionnaire

27 Do you have any comments or suggestions to help us improve the questionnaire?

Comments and suggestions, if any:

____

____

28 Did you delegate questions to other respondents?

☐ Yes ☐ No

If YES please provide name, email and phone number for any such other respondents:

other respondents name	email address	phone

29 How much of your time was taken up by the questionnaire, approximately?

Minutes of your time to complete (and organise completion): ____________

30 Your contribution will be acknowledged publicly unless you check this box:

(☐) Do not include us in the list of acknowledgements.

31 Would you like to receive a copy of the study report?

(☐) Request a copy of the report.

THANK YOU FOR YOUR CONTRIBUTION!

The **NetReAct** Study Team

on behalf of

the European Commission Joint Research Centre

Answer Code lists

Code A (discipline, see questions 4, 11,14, 19):

Code	Discipline	Code	Discipline
1	Z1 animal sciences	19	R5 physiology
2	Z2 aquatic sciences	20	I1 clinical medicine
3	Z3 microbiology	21	I2 experimental medicine
4	Z4 plant sciences	22	N1 neuroscience
5	Z5 pure and applied ecology	23	A agriculture, environment
6	Z6 veterinary sciences	24	N2 behaviour
7	B0 multidisciplinary biology	25	N3 psychology
8	B1 biochemistry/biophysics	26	C1 chemistry

9	B5 molecular biology	27	C2 chemical engineering
10	B2 cell biology	28	P physics
11	B3 genetics	29	G1 geosciences
12	B6 developmental biology	30	G2 space sciences
13	R1 anatomy and pathology	31	G3 hydrology
14	R2 biomaterials	32	G4 oceanography
15	R7 bioengineering	33	E1 engineering
16	R3 laboratory medicine	34	E2 computer science
17	R4 pharmacology	35	M mathematics
18	R6 toxicology	36	O others

Code B (rating, see questions 8, 9, 10, 25):

Code	Rating
1	essential
2	very important
3	important
4	low importance
5	no importance

Code C (funding source, see question 11, 14)

Code	Main source
1	own
2	other public
3	industry
4	**in Q11:** student; **in Q14:** post-doc
5	other

Code D (duration, see questions 11, 14)

Code	Duration
1	0-1 years
2	2-3 years
3	3+ years

Code E (activity, see questions 12, 15)

Code	Activity
1	post-doc or temporary research post
2	faculty or other permanent research post
3	other research and development post
4	other employment
5	no employment
6	dont know

Code F (organisation, see question 12, 15)

Code	Organisation
1	university
2	other public
3	private sector
4	not applicable
5	dont know

Code G (size of the group, collaboration, see question 6, 26)

Code	Size of the group / Collaboration activity
1	grown significantly (more than 20%)
2	grown somewhat
3	remained the same size
5	decreased somewhat
6	decreased significantly (more than 20%)