The global competition for talent: Life science and biotech careers, international mobility, and competitiveness

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APPENDICES

APPENDIX A: CILS SURVEY COLLECTORS AND INTERVIEWS

Table A.1: List of CiLS survey collectors and number of responses

	Frequency	Percent	Cumulative Percent
YEBN newsletter	86	14.5	14.5
YEBN website	90	15.2	29.6
Naturejobs	194	32.7	62.3
European Fed. of Biotechnology newsletter	29	4.9	67.2
Email to YEBN members	13	2.2	69.4
MDC Grad School, Germany	25	4.2	73.6
UniBern, Switzerland	14	2.4	75.9
YEBN members' link to friends and contacts	23	3.9	79.8
Email to YEBN's contacts (non-members)	23	3.9	83.7
EPFL, Switzerland	70	11.8	95.5
BTmag. eu Careers blog	18	3.0	98.5
ETH, Switzerland	9	1.5	100.0
Total	594	100.0	

Table A.2 List of interviews in Lithuania

Chairman of Lithuanian Science Council, member of Lithuanian Academy of Sciences and Professor of Chemistry, Vilnius University

Member of organization of returning migrants from US

Returning scientist and top manager at Institute of Biotechnology, Vilnius

Returning scientist working at Institute of Chemistry, Vilnius

Expert on migration and brain drain, Vilnius University

Expert on migration and brain drain, Public Policy and Management Institute

Table B.1 Levels of Education

Which of these best describes the highest level of education that you have ALREADY completed:

Answer Options	Response Percent	Response Count
Secondary school/high school	9.8%	58
Apprentice, technician, or higher training in life science (outside of university)	1.3%	8
Bachelor's or equivalent	16.7%	99
Master's or equivalent	43.1%	256
PhD	13.6%	81
Post-doc	12.3%	73
Other (please specify)	3.2%	19
Total		**594**

Table B.2 Twenty fields of graduate study of CiLS respondents, for highest level of education completed and current studies (Counts)

Highest level of education completed			Current studies		
	Post-doc	PhD/ MA		Post-Doc	PhD/ MA
Biotechnology	12	53	Molecular Biology	0	31
Molecular Biology	37	41	Biotechnology	0	25
Biochemistry	13	29	Cancer Research	1	24
Microbiology	13	15	Cell Biology	0	14
Genetics	9	13	Neurosciences	1	12
Cancer Research	26	12	Biochemistry	0	11
Immunology	10	12	Immunology	0	10
Bioinformatics	7	11	Genetics	0	7
Cell Biology	22	11	Infectious Diseases	1	7
Plant Sciences	2	11	Microbiology	0	7
Neurosciences	10	10	Biomedical & Tissue Engineering	1	6
Infectious Diseases	11	7	Pharmaceutical Sciences	0	5
Pharmaceutical Sciences	3	6	Plant Sciences	1	5
Animal Sciences	3	4	Developmental Biology	3	4
Developmental Biology	9	4	Bioinformatics	0	3

Medical Sciences	8	4	Proteomics	0	3
Physiology	3	4	Virology	0	3
Chemistry	3	3	Analytical Technology	0	2
Virology	8	3	Animal Sciences	0	2
Biocatalysis	1	2	Bioprocess Engineering	0	2
answered question	73	290	answered question	11	212

Table B.3 Cross-tabulation of citizenship by country of residence (at time of survey)

	Citizenship								
	WB Developing	India	EU 10	Germany	Italy	Spain	Switzerland	All other countries	Total
Currently live Count %									
India	0	77	0	1	0	0	0	0	78
	0.0	98.7	0.0	1.3	0.0	0.0	0.0	0.0	100.0
Germany	10	9	4	58	2	3	0	5	91
	11.0	9.9	4.4	63.7	2.2	3.3	0.0	5.5	100.0
Italy	1	1	0	0	33	0	0	1	36
	2.8	2.8	0.0	0.0	91.7	0.0	0.0	2.8	100.0
Spain	4	0	2	0	0	57	0	2	65
	6.2	0.0	3.1	0.0	0.0	87.7	0.0	3.1	100.0
Switzerland	15	5	6	8	8	2	40	21	105
	14.3	4.8	5.7	7.6	7.6	1.9	38.1	20.0	100.0
France	1	1	0	3	2	0	0	4	11
	9.1	9.1	0.0	27.3	18.2	0.0	0.0	36.4	100.0
The Netherlands	0	2	2	2	2	0	1	5	14
	0.0	14.3	14.3	14.3	14.3	0.0	7.1	35.7	100.0
Poland	0	0	16	0	0	0	0	0	16
	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Sweden	3	1	1	1	0	1	0	1	8
	37.5	12.5	12.5	12.5	0.0	12.5	0.0	12.5	100.0
UK	3	1	2	0	2	0	0	10	18
	16.7	5.6	11.1	0.0	11.1	0.0	0.0	55.6	100.0
US	3	2	2	2	0	2	0	14	25
	12.0	8.0	8.0	8.0	0.0	8.0	0.0	56.0	100.0

Table B.4 Residence of EU and Swiss citizens in CiLS survey

	Live in same country	Moved to other EU or Switzerland	Other
EU or CH Citizenship= 349	246 (70%)		
Central and Eastern Europe (EU-10) = 48	TOTAL 26 (54%)	19 (40%)	4
	Poland 16	10	1 (Japan)
	Latvia 3	0	0
	Lithuania 2	1	1 (Algeria)
	Hungary 0	2	0
	Slovakia 0	2	0
	Slovenia 1	1	0
	Bulgaria 1	2	1 (US)
	Romania 3	1	1 (US)
Germany = 76	58 (76%)	15 (20%)	3 (2 US, 1 India)
Italy = 49	33 (67%)	16 (33%)	0
Spain = 67	57 (85%)	7 (10%)	3 (2 US, 1 Canada)
Switzerland = 42	39 (93%)	1 (2%)	2 (1 Taiwan, 1 Canada)
Other EU = 67	33 (49%)		
France 17	4		
UK 12	9		
Netherlands 6	4		
Belgium 6	3		
Austria 5	2		
Portugal 5	4		
Ireland 5	3		
Denmark 4	2		
Sweden 4	1		
Luxembourg, Finland, Greece 1 each	1 (Finland)		

Table B.5 Countries included in Citizens of World Bank Developing Countries in the CiLS survey

Countries in CiLS sample included in World Bank Developing*	Counts
Algeria	1
Argentina	6
Bangladesh	3
Belize	1
Bosnia and Herzegovina	1
Brazil	3
Cameroon	1
Chile	3
Colombia	5
Croatia	4
Egypt	6
El Salvador	1
Ethiopia	1
Guatemala	1
Indonesia	1
Iran	7
Kazakhstan	1
Kenya	3
Malaysia	4
Mexico	8
Nigeria	7
Pakistan	12
Russia	8
Serbia	3
South Africa	1
Syria	1
Tunisia	1
Turkey	9
Ukraine	1
Venezuela	1
Yemen	1
Zimbabwe	1
Total	**107**

*China, due to differing patterns, and countries in EU are excluded. Croatia was not yet an EU member at the time the CiLS survey was conducted.

The following are activities related to the CiLS data at YEBN that I was actively involved in preparing:

Danilowicz, E. (2007). Careers on the Move. *Natur*e, 449(4), 1.

Rindoks, A. (2009) *Careers in Life Sciences: Skills and Hiring. Comparative analysis of the CiLS Life Scientists Survey and Companies Interviews*. Presentation at Satellite Event: Preparing Life Scientists for Work Lives: Which Complementary Skills are needed, European Congress on Biotechnology (ECB-14), Barcelona, Spain. 13 September.

Rindoks, A., & CiLS team. (2009). *Preliminary Results of Careers in Life Sciences Survey.* Presentation at the Youth Conference on European Life Science Careers (YCEULSC), Frankfurt, Germany. 12 February

Rindoks, A., & Danilowicz, E. (2008). International Science Careers Survey: Staying a Step Ahead. *New Biotechnology, 25*(2-3), 125.

Daniłowicz-Luebert, E. (2010). International science careers survey. Which skills really matter? Presentation of CiLS results at Naturejobs Career Expo, London, UK. 23 September.

Biotechnology statistics

First, collecting internationally comparative biotechnology statistics and information on the global scientific workforce is a relatively recent endeavor. I began thinking of this project while still a Master's degree student in 2005, a time when the OECD had completed an inventory of biotechnology statistics in different countries (van Beuzekom, 2004), but before the standardized statistics for Europe were available. Biotechnology has become a crucial part of life science research. The OECD first implemented a standard international definition of biotechnology in 2004: "Biotechnology is the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods or services." The first main OECD report using this definition was: Biotechnology Statistics 2009, reporting on data from. The reports issued prior to 2009 were based instead on various national statistics, drawing from various R&D surveys, which were not harmonized internationally in terms of types of information collected or in the definition of biotechnology.

The OECD's most recent full report using standardized statistics was *Biotechnology Statistics 2009,* reporting on data from 2006[46]. The reports issued prior to 2009 were based instead on various national statistics, drawing from various R&D surveys, which were not harmonized internationally. A list of the current key biotech indicators is listed below.

OECD Biotechnology Statistical Indicators (list last updated in October 2013)

1. *Biotechnology firms*

- KBI 1 Number of firms active in biotechnology, 2011 or latest available year
- KBI 2 Percentage of small biotechnology firms, 2011 or latest available year

2. Biotechnology R&D

- KBI 3 Biotechnology R&D expenditures in the business sector, 2011 or latest available year
- KBI 4 Biotechnology R&D intensity in the business sector, 2011 or latest available year
- KBI5 Percentage of biotechnology R&D expenditure by dedicated biotechnology R&D firms in the services sector, 2011 or latest available year
- KBI 6 Percentage of biotechnology R&D expenditure performed by small biotechnology/R&D firms, 2011 or latest available year

3. Public-sector biotechnology R&D

[46] At the time of writing, October 2013

- KBI 7 Intramural biotechnology R&D expenditures in the government and higher education sectors, millions of USD PPP, 2011 or latest available year
- KBI 8 Intramural biotechnology R&D expenditures in the government and higher education sectors as a percentage of total government and higher education sectors R&D expenditures, 2011 or latest available year

4. Biotechnology applications
- KBI 9 Percentage of dedicated biotechnology firms by application, latest available year
- KBI 10 Percentage of biotechnology R&D by application, latest available year

5. Biotechnology patents
- KBI 11 Share of countries in biotechnology patents filed under PCT, 2009-11
- KBI 12 Revealed technological advantage in biotechnology, 1999-2001 and 2009-11

Source: Accessed 10 October 2013
http://www.oecd.org/sti/biotech/keybiotechnologyindicators.htm

A key challenge for conducting comparative research on the biotech workforce is that counts on the types of companies involved varies, as it occurs in a range of different industries (healthcare, equipment, chemicals, etc.), with different functions, and frequently in companies that are not working solely in biotechnology. Comparative statistics of the biotechnology industry is assessed through data on number of companies, patents, and R&D spends, or data on publications. What is important to point out now is that while each of these measures points to various aspects to compare the size of the biotechnology industry and related innovation across various countries, what is missing is comparable data on the workforce.

In other words, various comparative reports present sometimes radically different statistical data even for basic information such as number of firms or employees. Therefore, while the EU had expresses explicit interest in biotechnology at that time the studies on the industry's structure tended to focus on regulation, patents, or funding, and not the workforce. Third, the biotechnology industry itself may be changing. Again, at the time of thinking of this study, biotechnology was relatively unknown by the masses, so to speak, and in Europe often negatively associated with genetically modified foods or cloning, and now developments related to biotech have received a more positive view, such as alternative fuels and 'green' and 'clean' tech. As demand for these new fields emerge, the dynamics of both skills needed from the workforce and employment structures (types of firms and where they are located) are likely also evolving and with it, the definition and classification of biotechnology may evolve too.

<u>The life science workforce and their international mobility</u>

Understandings of the life science workforce are also limited due to lack of internationally comparative statistical data. Internationally comparative statistics and the competitiveness of the biotechnology industry are assessed through data on number of companies, patents, and R&D spends, or data on publications. What is important to point out now is that while each of these measures points to various aspects to compare the

biotechnology industry and related innovation across different places, what is missing is comparable data on the workforce.

Although data on skilled migration tends not to be internationally comparable (given that they are often based on very specific qualifications for work or residence permits, as discussed in Chapter 2), there has been improved international data collection on international students in many countries, including some data by field of study. Internationally comparative statistics are more recent (Institute of International Education, 2008; OECD, 2007). International education statistics have been compiled through a partnership among the OECD, Eurostat, and UNESCO[47]. Understanding recent trends in international student mobility is therefore important for several reasons. First, as shown in Chapter 2, there have been substantial changes in student mobility in the past two decades, from 1.3 million students in 1990 to 4.1 million in 2010 (OECD, 2012, p. 362). Second, data for international students is more complete than comparable data on the international workforce. According to Inzelt (n.d., p. 3) :

> A detailed analysis of the impact of such efforts to enhance (international) mobility of HRST (human resources in science and technology) is burdened by the *lack of data and statistical information* on researchers not only in an internationally comparable way, but national sources are scattered and contain limited information too – even if the importance of this kind of information is well known. Availability of data is much better on cross-border *mobility of doctoral students,* than on researchers.

Therefore, although student migration is statistically lower than many other forms of migration, it is important for understanding new trends and employment in scientific sectors. The following sections aims to combine the best available data sources to highlight trends related to the mobility of scientists, and where possible life scientists, and focuses particularly at identifying new trends through data from the late 1990s onward, the period identified earlier as the time the global competition for talent emerged as a concept and concern.

Data collection on the scientific workforce is therefore very uneven across countries. The US has long had an interest in mobility of students as well as the science and engineering workforce, given its long-standing position as the leading destination for international students, and had been collecting data on international students since 1948, and conducting the Survey of Earned Doctorates (SED) since 1962. It also created the

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[47] There are two main definitions utilized. Some countries collect data on *international students*, which "refers to students who have crossed borders with the express intention to study. International students are those who are not residents of their country of study or those who received their prior education in another country" (Inzelt p. 9). The second statistical definition is based on foreign students, which instead looks at anyone who is foreign-born in the education system, rather than those who moved for education in particular. This is used by the OECD when data on international students is not available. This measure is less instructive to observing trends related to the expansion of international education and may contain immigrants who have been previously living in the country. The UNESCO Institute of Statistics' World Education Indicators Program also has a survey, funded by the World Bank, among developing countries, where national statistical data on students is not always available.

Science and Engineering Statistical Data System (SESTAT) in 1993, a database that provides detailed demographic and workforce characteristics by combining surveys from various science and engineering graduates in the US. The SESTAT database combines data from three surveys: Survey of Doctorate Recipients, National Survey of College Graduates, and the National Survey of Recent College Graduates and is funded by the US Census Bureau[48] (See https://sestat.nsf.gov/) and are conducted every other year. The OECD recently started a new statistical project called Careers of Doctorate Holders, which includes mobility as a key element, but at the moment the data is limited to survey data collected in 2007. Furthermore, the preliminary report concluded that there has been changes in international mobility in the past decades and particularly among younger cohorts, and therefore revised its standards for future data collection to individuals receiving their doctorate in the past 15 years (Auriol, 2010, p. 7). Therefore, the tool is still being developed and trends across time cannot be assessed yet. The European Commission has also aimed to increase the knowledge on research mobility within the EU member states, through two *Mobility patterns and career paths of Researchers* (MORE) studies to build both the statistical basis and understanding of motivations for researcher mobility across countries and sectors. The first was launched in late 2008 and the second in 2011.

In all of the surveys discussed in the previous paragraph, data for field of study are reported only in very wide categories. The data for the MORE2 study is available online[49], but life scientists fall under the wide category of "natural sciences and engineering and technology." The OECD's Careers of Doctorate Holders study groups the natural sciences together[50]. This means that comparison between various fields in the natural sciences is not possible with publicly available data. Therefore, significant gaps still exist, both in comparing the workforce across countries and in being able to match it with findings of other studies, such as the importance of regional specialization in attracting top researchers. Nonetheless, some information on the prominence of international mobility is reflected by these data sets.

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[48] http://www.nsf.gov/statistics/sestat/, Accessed 4 March 2015

[49] At http://www.more-2.eu/www/index.php?option=com_content&view=article&id=118&Itemid=138, Accessed 29 October 2013

[50] From data of graduates in mathematics; computer and information sciences (excluding hardware development and social aspects); physical sciences; chemical sciences; earth and environmental sciences; biological sciences (excluding medical and agricultural sciences); and other natural sciences (Auriol, Schaaper, & Felix, 2012, p. 69)

APPENDIX E: ATTRACTIVENESS OF TOP 5 COUNTRIES LISTED AS FIRST CHOICE IN CILS STUDY BY CATEGORIES

US	DE	CH	UK	Spain
Productivity: Research or scientific excellence				
It's the country where the research is the most interesting. Nobody can deny the quality research carried out in this part of world. So there is no question of its specific attraction. Because the United States are the Biotech's native country, and because it's easiest find a fund for biotech research. Finally because it's the land of the opportunity. Because US is developed so many policies and projects for research with modernized equipment in science and technology. I will be able to learn more especially in writing research grant, experiment planning, technique and skills. There are many different kinds of research seminar, conferences held in US from time to time. It is a good exposure to different types of research works.	As Germany is technologically very advanced in scientific research. Scientific heritage, excellent research background, world class research institutes. Germany is one of the countries with most advanced level in biotechnology research and highest number of biotech companies. They are one of the epicenters of cutting-edge research in the field of life science. Because it has many universities with developed departments that I think they are best in my field of study and my interest.	I love the level of research in Switzerland. Scientists are good and interactive. Good funding of research, close relationship between industry and research. Very good research institutes with good funding Booming Biotech / Medical engineering start-ups everywhere Because Biotech industry is highly developed here moreover all main biotech companies from all around the world have HQ here. It counts several good universities/institutes and biotech companies, as well as big pharmaceutical industries.	Very good balance between academic and industrial level of development and funding. Because of the trends in adopting new technologies with the traditional methods. In my opinion United Kingdom, and especially London, offers a wide range of opportunity in science /biotechnology field. UK is now one of the leader countries in Biotechnology. US companies (who still invest far more in biotech than any other country) are more likely to build sister companies first in the UK to enter the European market. I desire to study on microarray technology to develop my projects. The UK has improved technology in this subject. There are many renowned universities in United Kingdom like Edinburgh University, University of College London, King's College, Imperial London College and so on. These Universities are well-known for their research.	Growing research, new institutes At the time when Molecular Biology became important in the last century and seminal discoveries have been made, life science research has not been supported in Spain. After the repressive Regime of Franco, Spanish researchers managed to catch up with Europe and are now among leading scientists again. The vivid atmosphere and good funding provides a perfect research environment. There is an emerging market in life sciences.

US	DE	CH	UK	Spain
Opportunities				
This country considers your degree and research experience and offers good job opportunities like research assistants, professors, lecturer, Big pharmaceutical companies, Good universities etc. I think that there is the chance for everyone, especially who operate in scientific area. The biggest amount of jobs offers and not so strange requirements as in (my home country).	Because my interest area of work has a lot of possibilities in Germany. There are several companies and academic institutions that allow to get more opportunities to get work. It seems to me that job market for scientists is broader than in other countries.	Variety of work possibilities Because Switzerland has always been a country with a lot of opportunities for a graduate in life sciences.	Moving there in a few months, great opportunity in academia and industry. In my opinion United Kingdom, and especially London, offers a wide range of opportunity in science/biotechnology field.	In the field of biology, biotech and pharmaceutics it is an emerging country. I am convinced to go ahead with a career the environment has to be dynamic and give you opportunities. Switzerland is in this field is already saturated and as young and dynamic you don't always get your chance. On the other hand the emergence of Spain gives you a young environment open mind to new ideas which I believe is quite exciting.
Work ethic / Work culture				
The work culture is in top notch. Manner of working and communicating It's said to have a completely different way of focusing research.	I would like to work in this county because the way the work and experiments carried out in this country. The people are very disciplined. They are very precise and quality of the work is really better than any other part of the world. The reasons are many but the most important ones that I see, they are very systematic and organized.	Because my previous experience showed me that people in this country work seriously and with high degree of quality. I had the experience in working in academic field in Switzerland and I found it very well, and clever, organized.	I like England or Scotland, and I know some people that have been working, studying or researching there and have had a very good experience.	…produce good science and research. It was very simple for me to communicate with the whole research group**.**

US	DE	CH	UK	Spain
Lifestyle, culture & environmental reasons				
I love it.		Familiarity with the local language and culture Good range of leisure and cultural activities I believe that it's the best place & environment to live in Europe	No culture shock and understanding of the way things work both generally, and within specific areas such as academia. Attitude of scientists and British people in general	Like the culture and the ""life level"" I feel that Spanish people are very friendly and social. Lifestyle and climate are definitely things that fit me.
Diversity / International environment				
Because of its diversity. Diverse community, diverse people, diverse food			UK has a big name in life science research with multinational culture. Because in a UK there is a multicultural environment that allows the comparison and exchange of knowledge.	