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

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PART II: THE GLOBAL COMPETITION FOR TALENT IN PRACTICE – LIFE SCIENCE CAREERS, INTERNATIONAL MOBILITY, AND COMPETITIVENESS

PREFACE TO PART II

"Let me also say that even were it possible to force the professionals to stay home, it would be a foolish policy. Lack of congenial working conditions, absence of peer professionals to interact with, and resentment at being deprived of the chance to emigrate can lead to a wholly unproductive situation in which one has the body but not the brain. The brain is not a static thing; it can drain away faster sitting in the wrong place than when traveling abroad to Cambridge or Paris! So the only practical policy is to accommodate to the fact that outmigration of one's skilled citizens will surely occur."
(Bhagwati, 2004, p. 214)

The first part of this study set out to explore international changes that are structuring the global competition for talent. The story framing the global competition for talent grew largely from the expansion of the knowledge economy. Innovation and technology have been said to be both the key and engines of economic growth; they are both perceived to get economic growth started and propel it forward. The story behind the global competition for talent also involves a noticeable increase in young, educated migrants, and particularly students, to more diverse destinations, which has been supported only in part by new policies. These changes include new groups in the traditional immigration countries, for instance, the numerous IT workers coming from India since the 1990s to the United States. It also includes new groups and forms of migration to places that have not had a skilled migration policy per se, and often international student migration is among the first noticeable change. The increase in student migration is seen across the globe, including within developing countries. In the European context, there has been more discussion about the merits of skilled migration by both politicians and businesses.

In other words, it is increasingly recognized that human mobility forms an essential part of current processes of globalization, and is happening in different forms and patterns, in more places, and to a greater extent than before. Yet, one important critique of phrases like "the global competition for talent" is that they suggest a uniform phenomenon is taking shape; it is a blanketing phrase. In an attempt to catch a new phenomenon linked to new forms and interest in high-skilled international mobility, there is a risk that the phrase will instead be used without view of differentiation in situations. The strategy related to the global competition for talent can therefore vary substantially, not only across countries, but also across different fields of employment or topics of research.

There has long been international policy interest in supporting education or work for scientific and engineering fields. The acronym STEM (science, technology, engineering and mathematics) fields has become widely used in media and policy discussion, originating in the US (and now also used by the OECD), while the UK has adopted a similar discussion around the need to increase skills in SET (science, engineering, and technology), and Germany has had extensive discussion of MINT (mathematics, information sciences, natural sciences, and technology). While there may be debates on what to call it and which specific fields are included, the common view is that scientific, mathematics, and technical skills are crucial and study programs and research for these fields need to be supported and this discussion spans international borders, even in times of recession (albeit there may still be budget cuts).

At the same time, research has shown that skills shortages are nearly impossible for governments to predict. There is also the question of whether booming fields end up saturated, in that more individuals seek out these fields of study, with more expectations that a 'good' job will be available than the actual number of opportunities.

Scientific moves in particular have long been assessed through a paradigm of brain drain versus brain gain, although many researchers suggest the brain circulation paradigm is now more relevant (see e.g. Edler, Fier, & Grimpe, 2011; Gaillard & Gaillard, 1998; Guellec & Cervantes, 2002; Meyer, 2001). The brain gain and brain drain literature contains a judgment of a negative result for the sending country (brain drain) or positive result for the receiving country (brain gain), whereas attention to brain circulation more rightfully points out that new knowledge can be gained from migration and then utilized upon return.

Scientists, as a particular form of skilled migration, have also been discussed as 'scientific mobility.' I believe this term is more appropriate than 'brain circulation' which generally implies migration and later return to a less developed home country. The scientific mobility literature looks at international movements of scientists more generally, including the movement of scientists between two developed countries. In contrast, scientific mobility instead focuses on dynamics related to the career choice as a researcher. The topic of 'scientific mobility' has gained increasing attention in Europe due to a range of policies to support the R&D, including the ERA policies that facilitate international scientific moves (see Chapter 4); however statistics on the scientific workforce are lacking and fragmented.

The global competition for talent should not be seen as one phenomenon, but instead as a myriad of individual lifestyle choices, career paths, and structural influences acting together. While my own academic background has me approaching this topic first from a view of changes in mobility, it could just as well be approached from a view of human resources, skills and employer needs, or from that of political-economic systems, to name a few. Yet, the complexity of the global competition for talent does not mean that it cannot be understood in a deeper way, through carefully watching for statistical changes and finding examples that are of broad interest.

The second part of this study looks at the case of one area of employment important to the knowledge economy, the life sciences and biotechnology, as an exploratory study to identify some of the dynamics driving the global competition for talent. It addresses the main research question, **"Which patterns have influenced the development of the global competition for talent as observed in the life sciences/biotechnology in particular?"** The geographic focus is mainly on Europe, as compared to the often assumed top competitor, the United States, and individuals from developing countries, who would be expected to have different push-pull factors and motivations. The primary data is drawn from the perspective of the scientists, including both students and employees seeking careers in the fields of life sciences and biotechnology. The life sciences and biotechnology blend two aspects that were found to be important and discussed in Part I -- they are innovative, research-intensive fields of interest to governments and the international mobility of scientists is also a topic of interest for policy and competitiveness. The next few sections will give a brief overview of the biotechnology industry and an overview of scientific mobility and skills shortages relevant to the global competition for talent in the life sciences.

A BRIEF INTRODUCTION TO THE BIOTECHNOLOGY INDUSTRY

Biotechnology has been one of the rapidly developing areas within the knowledge economy of the past decade. With a broad definition that includes "knowledge, goods, and services" and continual expansion into new research areas, biotechnology plays an increasing role across various aspects of the life sciences research and hence company types. Conducting international research on the biotechnology industry is complex, given the diversity of topics considered as part of biotechnology.

One other common way to further define biotechnology is by four main categories, which are based mostly on the function of the biotechnology, or how it is applied: red, white, green, and blue. Red biotechnology is related to medicine and health care biotechnology; white to industrial processes; green to agriculture; and blue to marine organisms. Within Europe, red biotechnology is the largest (Ernst & Young & EuropaBio, 2012, p. 88). White biotechnology is rapidly growing and has been supported by numerous policies. The three main areas of research and utility for white biotechnology are industrial production, biomass, and biofuels. White biotechnology can improve industrial processes, for instance an enzyme may be used that allows for fewer stages to be needed in production. White biotechnology is seen as key way for companies in many sectors to both reduce their production costs and reduce the amount of dangerous wastes. Developing biofuels is also currently a key goal that falls under the category of white biotechnology. Green biotechnology involves research related to plants, animals and food. Green biotechnology is also associated with genetically modified food, which has been viewed as increasing agricultural outputs due to having more resilient plants for a given environment. This form of green biotechnology is underdeveloped in Europe (Ernst & Young & EuropaBio, 2012, p. 89), due to having some of the strictest legislation in the world regarding use of genetically modified organisms. Blue biotechnology researches how marine organisms can be used and is the only form of biotechnology that is defined based on its research source rather than the products. Its applications can be for any range of functions, including medicines, industry, and environmental cleanup. Blue biotechnology is considered the least mature sector of biotechnology research globally and its role within global and European R&D is still marginal. Its use is reported much less frequently than the other forms of biotechnology. The varying applications to biotechnology also mean that the structure of the biotechnology sector may differ substantially in various places, being strong in certain research areas and weaker in others.

Biotechnology is not necessarily a large economic sector in some OECD countries, yet due to the topics it covers, particularly healthcare and improving the environment, it is considered an important part of the knowledge economy globally, for both developing and developed countries. The US is seen as the top country in biotechnology, as is discussed in more detail in Chapter 8, which looks at statistics for biotechnology competitiveness. Much of the research on the biotechnology industry and its workforce is therefore also found in the US.

SKILLS SHORTAGES IN THE LIFE SCIENCES AND BIOTECH SECTOR

There were indications in the early 2000s that the high-growth life science and biotechnology industry faces a shortage of workers in many countries. The fast-changing nature of the industry and impact of new innovations also make predicting labor shortages difficult. Furthermore, some studies found that life science graduate students (or potential life science students) are ill-informed about specific skills needed for biotechnology or life science research career (European Science Foundation, 2009; Human Frontier Science Program & European Science Foundation, 2002; New Economic Systems & The Leonard Resource Group, 2004, pp. 24-26). Biotech industry articles also indicate that there were crucial shortages of skilled workers in the biotech sector both on a global level and within Europe (EPOHITE 2003, p.39-40; Sevier and Dahms 2002; Gwynne 2004; Hodgson 2006). These concerns are compounded by rapid growth and competition - 55% of European biotech companies were less than five years old in 2004 (Critical I 2006, p. 9). As more regions and countries aim to build a biotechnology sector, competition for qualified employees increases globally. US scientific advantage has often been attributed in part to its ability to attract talented foreigners (see Peri 2005; Gordon 2004), while in comparison, 'brain drain' has been considered as a barrier to European scientific advancement (Mergent 2004, p.1). There have been fears that European trained scientists will leave to work in the US or elsewhere, which may also lead to lack of qualified personnel in certain regions or fields of expertise.

Biotechnology industry articles suggest that a lack of qualified personnel creates challenges that may hinder the industry's success. There are indications that the growing biotechnology industry faces a shortage of workers in many countries and that national education programs alone may not be enough to remedy it. Science and biotech industry publications have contained sections devoted to the need and use of immigrant labor in life science sector. For example, Sevier and Dahms (2002) state, "Although the biotechnology industry has encouraged US educational institutions to increase the production of specialists in phase with industry needs, there has been a continual shortfall in a variety of areas and expertise, requiring access to foreign workers outside of the US labor pool" (p. 955). Gwynne (2004) similarly reports, "Whether they are based in Europe or Asia, life science organizations face a common problem: Their own countries generally do not produce enough top notch scientists to satisfy their needs." Furthermore, as more regions and countries support the growth of a biotechnology sector, international competition for qualified employees mounts. Given the demands of the knowledge economy and economic changes, these observations require further investigation.

Sumption (2011) explains why there are difficulties for governments to assess the link between vacancies and skills shortages:

> The number of unfilled vacancies provides a potential measure, but occupations with short job tenure and high turnover experience higher vacancy rates even when plenty of job seekers are available to work. And more fundamentally, the fact that employers would like to find workers with a particular skill set does not mean they can realistically expect to find them.
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> To see why, consider a firm designing software to help farmers track the genetic characteristics of rare breeds of cows. Ideally, they would like to hire a software programmer who understands cow breeding and genetics. But how many of these people

> exist? This is not a case of a shortage in expert programmer-breeder-geneticists, but rather an instance where an employer must lower their recruitment expectations.
>
> During the economic boom of the 1990s, which was fueled in large part by advances in the field of technology, US employers did exactly that. Employment in the IT industry ramped up at an impressive speed, and firms hired much less experienced candidates. When the dot-com crash reduced demand for their services, firms once again raised their expectations and began to hire more highly qualified workers. Was there a shortage of qualified IT workers during the boom? Did that shortage cease to exist because employers "made do" with less qualified employees? The answer is not clear-cut.

Although current and fear of future skills shortages have been reported in the media for scientific and technical sectors, there is less research that looks at individual areas to show what this means in practice.

CHARACTERISTIC FEATURES OF SCIENTIFIC MOBILITY AS A FORM OF SKILLED MIGRATION

The term scientific mobility in the academic literature is frequently cited from the research of Mahroum (2000a; 2000b; 2000c) and Ackers and her team (see e.g., Ackers, 2005a; Gill, 2005; Morano-Foadi, 2005) on scientific mobility in select European countries. Scientific mobility is linked with the broader literature on skilled migration, as a specific type of skilled mobility. Much of this research also focuses on academic settings, in part due to the greater visibility of these jobs through online databases as well as likely due to the EU's policy on promoting mobility of researchers, who are often researchers in academic settings. However, scientific mobility can also apply to scientists working within industry or businesses, and is particularly relevant to individuals working in R&D. The term could also apply to certain positions in international companies, for instance in multinational pharmaceutical firms, which may require both technical and other, particularly management or sales, skills. Another important reason to use the term scientific mobility is that it takes into account that there may be any number of international destinations in a scientific career and also includes stays of diverse durations. This is a good contrast against 'skilled migration' research, which in many cases looks at a single destination and at times is limited to only permanent moves. Scientific mobility was also deemed as more appropriate than the brain drain/brain gain/brain circulation concepts, which also typically only analyze effects for only the home country versus one country of destination.

A brief review of some of the recent literature on scientific mobility is given below, with a focus on discussing the extent to which scientists move abroad as part of their career and their motivations for moving to help frame the discussion of scientific mobility that arises from the CiLS survey results, discussed throughout the remaining chapters.

Within the discussions of scientific mobility, it is often assumed that moving across national borders is a positive way to either build a career and also is seen to reflect the status of an institution. As Ackers (2008, p. 418) explains,

> Academic careers, especially in the natural sciences, have long been associated with high levels of physical (geographical) mobility. Over time this 'practice' of mobility has become deeply embedded in career structures to the point at which it has become an 'expectation.'

She further argues that there are multiple forms of international collaboration in the sciences possible today, including shorter-term visits, and moving abroad should not be regarded as the only, or most valued, strategy of internationalization among scientists. Schiermeier (2011, p. 563) expresses a similar view:

> Changing countries has become a rite of passage for many young researchers, especially in Europe, where cross-border mobility is common. The call for mobility has become the motivating mantra of organizations such as the Marie Curie fellowship programme, which promotes and supports mobility across Europe. In Germany, for example, to avoid academic 'inbreeding', in which universities hire their own graduates as professors, university tenure rules require scientists to change labs during the course of their postdoc or graduate education, and trips abroad to the United States or elsewhere are all but expected. In many countries, recruiters and funding agencies see international mobility as a mark of an applicant's ability and dedication, making changing labs a key to scientists' professional success almost everywhere.

Schiermeier further argues that some scientists need to move abroad to access the best labs in their fields, but may also be disenchanted when they expect that things will be 'better' abroad than in their home country (p.564).

Meyer, Kaplan and Charum (2001) discuss that scientists and engineers have long been one of the most internationally mobile groups, but what has changed more recently is a greater dispersion of where they go to and new forms of scientific networks, which are linked to the increased transnational nature of scientific work. Some scholars also argue for the need to understand scientific student and researcher mobility patterns of and constraints in relation to gender, family concerns, and the effect of a move on the partner's career (Ackers, 2003; Geddie, 2013).

Less is understood about variations in scientific mobility across fields of study, countries, and employers, and very specific norms may guide patterns for each of these. For instance, Vallas and Kleinman (2008), argue that studies looking at life science jobs in either industry or in academia have limited understanding of career dynamics by ignoring 'cultural-ideological processes,' or in other words norms and behaviors often exhibited in various life science institutions[26] (p.288). I would like to add to their critique that it is not only institutional norms

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[26] For example, these authors note that academic researchers tend to be reluctant to discuss their work with colleagues until it is published, whereas those in industry benefited greater from information sharing and teamwork with colleagues at all stages of a research project.

that matter, but also the accepted norms and values that scientists hold and which guide their career decisions, including whether or not they hold an ‘expectation’ of international mobility. In the migration literature, it is long accepted that some countries or areas have higher rates of mobility than others, but less is known about specific fields of work and the individuals’ expectations within their own careers.

Brain circulation has become a very pervasive topic in policy discussions. Yet, despite the policy interest in developing research and for specific fields such as biotechnology, and the expected high mobility as part of the career path, very little is understood in regards to mobility decisions of the scientists. Thorn and Holm-Nielsen (2008) tried to identify some of the push-pull factors for scientists from developing countries. They argue, “These decisions are not well understood and documented empirically, especially as regards researchers and scientists compared to other highly skilled migrants” (p.146). Although they hoped to model how development in the home country versus abroad effect migration decisions by using three data sources: “data from the World Development Indicators of economic growth rates, The Global Competitiveness report on the rule of law and the quality of public services, and OECD data on R&D expenditure as a percentage of GDP” (p. 151), they found none of their inputs to be a good fit with the data. They stated, “Consequently, the available data do not shed much light on what motivate researchers and scientists to migrate and return to their country of origin.” (p. 151).

Some research shows that the motivations of life scientists’ moves differ in part from other types of skilled migrants, including other types of scientists and engineers. Mahroum (2000a) found:

> Engineers and technicians, for example, are reportedly pulled and pushed primarily by economic factors. They go where this skill are most needed and most rewarded. In contrast, mobility among researchers and scientists is a normal part of scientific life and a well established norm. Researchers and scientists are motivated mainly by the content of their work and the concrete conditions under which they conduct their research. This assertion is substantiated by Shapin (1998) who – as part of an analysis on the role of trust in science – finds that scientists are attracted towards expertise and the institutions that have a reputation for being cutting-edge.” (as summarized by Thorn & Holm-Nielsen, 2008, pp. 151-152)

The potential for conducting high-quality scientific research in ideally a prestigious location is considered as one of the strongest motivating factors of scientific mobility (see e.g. Delicado, 2010; Díaz-Briquets & Cheney, 2003; Guth & Gill, 2008) and is considered to be more important than salary (Wood, 2004, p. 113). While salary or financial rewards can be an important factor for some individuals, it is found that it generally intrinsic motivations are considered in addition to the purely financial reasons (Lam, 2011).

Destination choice as linked to the broader range of choices due to globalization and institutional changes, such as from more countries adopting skilled migration policies for the first time and larger scale student migration, have scarcely been discussed. Much of the research discussing the global competition for talent as applied to scientists assumes that the US will be the top destination choice for most skilled migrants (Reiner, 2010), followed by the UK. However, as has been argued by (Laudel, 2005, p. 378):

> While there is a widespread feeling that 'whoever can go to the USA does so and tries to stay there', we have at best only anecdotal evidence of this happening, and less to explain whether it does so across the entire spectrum of science.

The assumed top destination choices have been based on factors such as past patterns of migration, economic strength of these countries, perception of widespread opportunities, the English-language environment, image as having diverse and/or open societies, and the competiveness of their universities and companies which allow for greater returns on human capital investments.

State et al. (2014) recently published the results of their study, which looks at international mobility of professionals globally from 1990-2012 by analyzing LinkedIn data, and focusing particularly on migration to the US versus other countries. Although they do not focus on scientific mobility specifically, STEM (science, technology, engineering, and mathematics) employment versus any other field is analyzed. Their approach of using LinkedIn data is a novel way to examine international migration of professionals on a more global scale. These authors recognize that one short-coming of their design is that citizenship cannot be determined. This means that little can be said about return migration of US citizens or circular migration. Furthermore, not all professionals used LinkedIn. Their data shows a drop in the percentage of migrants choosing the US as a destination for both stem fields and other fields, and across all levels of higher education. They attribute this decline in the attractiveness of the US to both the economic recession as well as the changing global systems of migration. Notably, they found:

> …while the U.S. became a less prominent destination for professional migrations during the 2000s, Europe and Canada also saw a decrease in their share of the world's professional migration flows – albeit a gentler one – while Australia and Oceania, Africa and Latin America increased their proportional intake. The most prominent increase was recorded for Asian countries, which attracted, in sample, a cumulative 25% of the world's professional migrants in 2012, compared to only 10% in the year 2000. (p.4)

They argue for better recognition in the decline of popularity in the US as a destination due to both policy reasons and changing global structural dynamics. Their data also shows that the number of international students going to the US was declining in the early 2000s but was again on the upswing from 2010-2012 (p.3).

In conclusion, the literature on scientific mobility provides some information on its main characteristics and how it may differ from other forms of mobility. First of all, there is a long history of scientific mobility and it has been said to be an integrated part of the career path. There is a widespread 'expectation of mobility,' which is relevant to scientists both in developing and developed countries, although the rates and forms of mobility will differ some across various countries. Scientists are said to be driven primarily by wanting to produce quality research, rather than by financial motives. The US has long been considered the top destination choice for scientists, but its position as the leading destination is being questioned within new dynamics of global, international migration.

Reaching for the stars: Star scientists and international mobility

Another area of interest within the research on scientific mobility is on 'star' scientists, a body of literature that was briefly mentioned in the discussion on 'talent' in the analytical framework in Chapter 3. The research on star scientists is important to mention, as this is an important subset for understanding the global competition for talent, whereby talent is defined more specifically as *individuals* who are seen as especially strong in their respective field. It is also important as a great deal of work has been done regarding star life scientists. This topic has been brought to attention by the work of Zucker and Darby for over fifteen years and only a portion of their work that represent some of the key findings are listed below. A good summary of their work, and particularly that which is related to international mobility, can be found in Zucker and Darby (2007). Their research has focused mostly on 'stars' in the biosciences, particularly genetic sequencing, and biotechnology and has involved research both on the US as well as other situations globally. Their work defining stars based on their work in genetic sequencing is relevant up to 1989, when new technology changed the need for these skills due to automatizing the process, and afterwards their studies are typically based on ISI citation indexes of publications. These authors demonstrate through a series of papers, and by analyzing a range of hypotheses, that breakthrough scientific discoveries of even one individual can have a profound impact on the innovation and hence productivity of the surrounding region (see e.g. Zucker & Darby, 2006; Zucker & Darby, 2007). Zucker and Darby (2007, p.6) discusses that although few scientists are involved in commercialization of research in the US, the firms that do have star scientists working for them have a much higher rate of staying in business for a couple of decades. Zucker, Darby and Armstrong (2002) focused on the 'star' scientists from the top 112 research universities in the US who made key discoveries in the field of genetics. They found that many of these star scientists were also employed with exclusive contracts by the firms that bring products to market or in co-publications with authors from these firms. This is a strong indication that the knowledge is embodied by the individual who discovered it, and cannot be easily replicated without intensive knowledge of the lab work and process through which it occurred. Due to institutional and legislative differences, the frequency of academics having industry contracts and the terms of those contracts will vary greatly by country. Zucker and Darby (2007) also look at the percentage of star bioscientists from 1973-1989 tied to firms in various countries. It ranged from a high of 42% in Japan, to none of the star bioscientists in Germany or Canada in that time period. In other words, only some knowledge is commercialized and converted into products and in this case the knowledge is also bound to a specific company; but in many other cases it is for advancing academic understanding in that particular field. Zucker and Darby (2006) found that generally star scientists around the world cluster in specific cities. An exception is that there are high return migration rates of foreign star scientists , who move in particular from the US back to their home country, when it had developed scientific strength. This finding also points to the need for more studies of scientific mobility in diverse countries, to see if circular migration is particular to the institutional and work conditions in the US, or if it reflects a broader trend.

Star scientists and their innovation have been found to have an effect on regional innovation, not only because of their own research, but also because they draw other scientists to the area. Star scientists tend to go where the best facilities and support are available, and where they can benefit from networks with other strong scientists, which means that top regions have a double advantage. They are more productive from new discoveries, and at times the commercialization of these discoveries, and these regions are also better able to attract more 'talent' in the future. Zucker and Darby (2006, p. 2) also find that 'star' scientists tend to "become more concentrated over time, moving from areas with relatively few peers to those with many in their discipline." Ackers (2005b) found a similar result indicating 'clustering' towards specific institutions of 'networks of excellence' in Europe when examining Marie Curie scholarship holders.

A similar clustering effect was reported by Millard (2005) in research on scientific clustering in the UK. Mahroum (2000c, p. 517) notes that there is a cyclical effect as well:

> Prestige, which is usually built over a long period of time, increases access to resources, which in turn increases the level of faculty scholarship, and thus yields more institutional prestige— which again increases access to more resources. Research has shown that because of this cyclical effect, institutional prestige yields cumulative advantages for its purveyors over time which increase subsequent opportunities for higher achievements.

Mahroum argues that institutions that have gained such prestige are able to continue to receive strong resources, such as funding, even in times when their scientific productivity has decreased. Yet, as Zucker and Darby note in their work, new and strong scientific regions have also been able to emerge, for instance, in China. These areas are not necessarily hubs for attracting scientists globally, although there is often a considerable amount of return migration contributing to the scientific growth, but rather have demonstrated high research growth rates in recent years.

Star scientists and their effects on firms have since been of interest and some researchers have applied the findings of Zucker et al. to examine other cases such as Germany (Schiller & Diez, 2010), Canada (Schiffauerova & Beaudry, 2011), France (Corolleur, Carrere, & Mangematin, 2004), and Zucker and Darby (2001) themselves have also looked closely at the case of Japan.

Schiller and Diez (2010, p. 285) found that among star scientist in Germany, younger scientists tended to maintain academic collaborations, and only the more-established scientists were building long-term ties with industry. These star scientists could form ties with relevant industries for their research and this decision is based on quality, regardless of their own geographic location (p.287).

Trippl (2013) aimed to expand the research on 'star scientists' to better understand, the top regions where they are found, and also the extent they have moved internationally. Trippl's paper draws on a survey of 720 scientists conducted in 2008, based on the most productive scientists as defined by the ISI citation index, for any scientific discipline, identifying the most cited 250 people by subject category (natural sciences; agricultural sciences; engineering and technology; medical and health sciences; and social sciences). The survey was global, but the majority of the top scientists in the citation indexes are based in either the US (56.6% of the sample) or Europe

(28.4%) and 70% of the total were based at universities, 18% at other research institutes, and only 2% working in companies. Her main conclusions were that star scientists are clustered in very few cities in the US and Europe. Trippl details out which cities attract scientists and the percentage of mobile and non-mobile star scientists in each. The main difference in patterns that she found is that the US has a much larger percentage of foreign-born scientists, most of who had been in the US for several decades, while at the same time native-born scientists also stayed. Some of the top US cities had a workforce where more than half of the scientists had not ever moved from that region. The key European cities had a different mobility composition. They were more likely to have scientists who had returned to their home country after being abroad. Furthermore, some cities in Europe were seen as highly productive academic environments, yet were not the locations of work for any of the 'top' scientists. This pointed to potential institutional or policy differences driving the attractiveness of various locations.

Trippl's work is interesting to better understand past scientific mobility in a more international context, an under-researched topic, but it does not reflect *recent* changes in scientific mobility for several reasons. The first reason is due to the sampling method. Not surprisingly, the most productive scientists in terms of publication records, tended to be based at academic institutions and were older, on average 65 years old and predominantly male (93%) (Trippl, 2013). Furthermore, the study covered all disciplines, with half of the scientists were working in the natural sciences. This method therefore calls attention to academic institutions that have produced the most papers historically, and as can be expected, the top regions are where the world's most elite universities are found, such as Harvard, Cambridge, Oxford, and other universities with global acclaim. It does not necessarily capture scientists that are active in patenting new innovations, but are not publishing, or those who are applying innovations to bring new products to market. Furthermore, it cannot identify places that have been competitive in one specific field, such as biotechnology. Third, the older, top scientists are more likely to have tenured positions, meaning academic appointments for life, than younger academics would, which likely limits their international mobility to shorter-term visits and only occasionally would they undertake new employment positions. With these caveats in place, it becomes clear that the work of Trippl should be interpreted as representing past scientific mobility, which was occurring mainly in the 1960s-90s.

The research on 'star scientists' is interesting to better understand scientific mobility and the importance of top regions and the best scientists. Yet, these studies' sampling method means that they address a different group than the CiLS survey, which has more data on scientists who are younger and hence at an earlier phase of their career. These young scientists have experienced different career possibilities, due to the changes in the career structure (as discussed in Chapter 5), increasing student and scientific mobility to and from more countries, and changing biotech competitiveness, that is to say strengths and weaknesses in comparative perspective across countries, and also within new, emerging fields of study and research topics.

Part II of this study aims to add more understanding to changing mobility today by looking at three aspects related to the life science and biotechnology workforce: careers, competitiveness and international mobility. Part II analyzes the results of the Careers in Life Sciences (CiLS) study, starting from a broad, global perspective, and gradually sifting down to better understand the influence of differences, particularly on the national level, on individual career decisions. In this way, it explores both what are global and what are local drivers of biotechnology career goals and particularly international mobility decisions, as observed through the CiLS study. The chapters in Part II will use the CiLS data related to this topic to look more in depth at specifically at life scientists' career path preferences (Chapter 5), patterns of international mobility and its importance for life science careers (Chapter 6), and the factors used for selecting a destination to move to for scientific work (Chapter 7). Chapter 8 adds additional information to better understand the competitiveness and opportunity structure for biotechnology and its potential influence on international mobility in life science careers. The conclusion, Chapter 9, summarizes the results within the 4P (people, place, productivity and policy) analytic framework that was introduced in Chapter 3.

All the discussion in the chapters up to this point have focused on dynamics that affect the global competition for talent and the competitiveness in various countries. But what can be said about the role of the workforce and their career preferences in shaping the global competition for talent? The next few chapters will use the CiLS data related to this topic to look more in depth at specifically at life scientists' attitudes towards international mobility, its importance for life science careers, the factors used for selecting a destination to move to (Chapter 7), and the desired places for moving for work in the life sciences and biotechnology (Chapter 8).