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**INTERNATIONAL ACADEMIC MOBILITY:
Towards a Concentration of the Minds in Europe***

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ABSTRACT

The global competition and related international academic mobility in science and research is rising. Within this context, Europe faces quantitative skills shortages, including an estimate of between 800,000 and one million researchers. Within Europe skills imbalances and mismatches increase, with a growing divergence between countries and regions, in particular between the North and South, in terms of their ability to invest and attract human and financial capital for R&D. As a result intra-European mobility is not only on the rise, but may easily turn from an intended brain circulation into a brain drain – brain gain situation. From a qualitative perspective solutions to the skills shortages and imbalances relevant to science and innovation require the training of a broad mix of skills, which is currently provided to only in a minority of students in European higher education institutions and programmes. Will the intra-European flows of human and financial capital for R&D result in a further concentration of the minds in a limited number of regions or hubs in Europe? Is this (un)avoidable or (un)desirable? The further concentration of talent appears to be Europe's fate. These forces play out quite differently across the various disciplinary fields. In general the "STEM fields" (including engineering, natural, life and medical sciences) are already most internationalized and especially their experimental branches require the highest concentration of financial and human resources for large-scale and high-tech research infrastructure. The current combination of mobility and funding flows and trends seems to cause an increasing concentration of especially high-tech research capacity (in the natural and life sciences) in a limited number of regional hubs, which is likely to the detriment of the broad comprehensive profile of universities in certain weaker regions and countries in Europe. Those institutions may have to choose more specialized profiles, focusing more on less (human and financial) capital-intensive fields in the social sciences and the humanities.

Keywords: Academic Mobility, International Research Careers, Skills Shortages, R&D Concentration, University Profiles

INTRODUCTION: THE CHANGING GLOBAL LANDSCAPE FOR ACADEMIC MOBILITY

The recently published global map of the top 500 universities in the world¹, shows the strong concentration of the proclaimed top universities in a few particular regions of the world: North America (in particular the east and west coasts of the US), Europe (especially the north-western part of it), Asia (mostly Japan and China), and some in Oceania (Australia's south-east coast). An analysis of the flows of international students and faculty² confirms this geography as it displays the global scientific powerhouses and thus global magnets for academic talent. These hot spots attract the largest concentrations of mobile academics. Globally, relatively few institutions provide doctoral education. This ability to attract talent from around the world on a highly competitive basis allows these institutions to further strengthen their capacity, and as propelled through the rankings - also their reputation. In this sense, the current geography may also be guiding future mobility and an even stronger concentration may occur between and even within these regions. In other words, unless extra efforts are made to build capacity elsewhere, the current mobility flows tend to strongly favour established institutions in a limited number of world regions.

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Yet, such efforts are being made indeed, and as a result, the global (im)balance could be shifting. In general the so-called BRICS countries (Brazil, Russia, India, China, and South Africa) are aiming to build capacity to match the traditional research centres in Europe, Japan and the United States. But until recently, even with these emerging countries entering the field, research capacity was still highly concentrated in a few regions. As of 2010 the EU, Japan and US still carried out three quarters of the world's R&D. Yet, the rise of new Asian scientific powerhouses could change the global scene. More Asian governments now view science as integral to economic growth and consequently develop their science infrastructures. This holds especially for China, South Korea, Taiwan, and Singapore. China's growth in R&D spending has been spectacular over the last decade with over 20 percent annually and it now produces more academic papers than any country apart from the US³. The rise of newly emerging science powerhouses in Asia provokes questions of what the impact will be on science and in particular, what a shift of scientific power to Asia would mean for flows of scientific talent from east to west and for cooperation with Asian partners.

A recent ADB/OECD/ILO report⁴ suggests such shifts in global flows. The flow of skilled migration from Asia to OECD countries has grown significantly. In 2011, Asians accounted for one third of all migrants to OECD countries and more than half of the recent Asian migrants in OECD countries are highly educated. Students from Asia represent 52% of all international students in the OECD, although more than three quarters of them are concentrated in only four countries: the United States, Australia, the United Kingdom, and Japan. However, in recent years, more Asian countries, in particular China and South Korea, have joined the competition for global talent. And China has already emerged as the second most important destination country of Asian students after the United States and the third largest for international students generally. A recent UNESCO report⁵ confirms the growing trend for Asian countries to host internationally mobile students (apart from Japan and China, also Singapore, Malaysia, South Korea, and Taiwan have such policies) although (still) primarily from other Asian countries⁶. The rise of Asian countries as scientific powerhouses is accompanied by increasing intra-Asian research collaboration.

The United States, with the largest intake of Asian students and academics, fears a decline of flows from Asia to its universities and R&D centers. However, the strong development of undergraduate degrees in Asia still seems to generate more supply for the US in postgraduate training. For the moment the US-Asia connection seems to remain strong, including international scientific collaborations. This may for the short-medium term remain the way Asia is building capacity, i.e. sending their most talented students for graduate training to the US, hoping that they return with state-of-the-art scientific knowledge. And increasingly stimulating them actually do so. But do they return? So far the success of China's "sea turtle policy" is just moderate and the US is undertaking extra efforts to increase "stay rates".

Europe as whole has, apart from the United Kingdom, benefited much less from the inflow of Asian students, as compared to the US. European mobility is mainly intra-European (over 90 per cent of the mobility of students). A lot and perhaps too much attention has been devoted to intra-European collaboration over the last decades. This is also reflected in a weaker research collaboration between Europe and Asia, as compared to that between Asia and the US. Does this imply that Europe is being bypassed by the Asian scientific rise? And what will be the implications of these trends for the geography of science and innovation beyond Europe's academic sector, for instance for the relocation of corporate R&D? Will this affect Europe with its strongly ageing population and predicted skills shortages (even) more than other regions?

Before we discuss these questions regarding a changing global landscape for academic mobility, we first want to take a closer look at the reasons why scientists migrate and countries are attempting to attract them.

WHY INTERNATIONAL ACADEMIC MOBILITY IS ON THE RISE

Research is becoming an ever more global activity, as scientists all over the world communicate, share data, and travel (from almost all countries) with unprecedented ease. International mobility of academics has risen over the last decades, as will be illustrated in the next section. Mobility can be explained by both push and pull factors, and often a combination of them.

Economic imbalances across countries and regions may push individuals to seek better academic career opportunities. The OECD⁷ identified potential increases in earnings as one of the most important reasons why people migrate. Scientists are particularly attracted to better science infrastructure and funding, better working conditions and also higher salaries. The decision to leave the home country is thus often led by the desire to go where 'good science' can be achieved. Key reasons why highly skilled researchers in the IT and biotechnology sectors moved to the UK were for example the desire to work with 'leading edge researchers', 'state of the art equipment', and in a 'meritocratic system'⁸. Common language, geographical proximity, and political tensions may also play a role⁹. Auriol et al¹⁰ also found that citizens with a doctorate mostly go abroad or return for academic reasons or job related economic factors, rather than for family or personal reasons. Strong evidence was for instance found in the decision to go abroad for doctorate holders from Portugal, Turkey, and Spain.

Pull factors for mobility are often provided by deliberate national policies, based on the general belief that that attracting international talents helps to ensure that a country plays a leading role in research and innovation. Based on this rationale, many countries attract international students to doctoral programmes and more generally aim to attract tertiary-level graduates as knowledge workers. Retaining international students for employment is the objective of an increasing number of countries¹¹. Whereas international students were previously mainly understood as part of temporary migration movements, they are now increasingly seen as a source of high skilled labour migration. OECD estimates that in about 15-30 per cent of cases international study is the first step toward eventual settlement in the host country. In Japan and France, almost half of all new permanent labor migration even comes directly from the study route. It should be noted that this concerns degree mobility and not students who study abroad only for a part of their degree.

The advantage of a domestic degree which is easier understood by employers in the host country over short term mobility which accounts towards a foreign degree seems to play a role, in spite of efforts to facilitate international degree recognition. As student-led migration is becoming part of global talent contest, international degree students are thus being approached more often as part of a broader strategy to promote skills development and mobility. This entails a range of measures including allowances to work during studies, to change visa status after graduation, or special job search visas for graduates, allowing international students to work and to seek employment after graduation in the host country. For this purpose, the European Parliament adopted in early 2014 a new guideline that allows international students to work (without restrictions on the number of hours) during their studies and to stay 1,5 years after graduation to search for employment or start up a company. As part of such broader strategies, the EU also aims to attract researchers, as facilitated through the Blue Card policy (the EU's equivalent of the US Green Card, allowing high-skilled non-EU citizens to work and live in almost any country within the EU). In certain cases, countries also aim to attract researchers who emigrated back to the country of origin (for instance in India and in China). China introduced a number of financial incentive tools to attract researchers from abroad. The 1000 Talent Plan provides, under certain conditions, leading researchers in the domains of science and technology with a substantial lump-sum subsidy and a research subsidy in addition to the regular salary.

Research provides supporting evidence that diversity in the labour force generally contributes to entrepreneurship and innovation¹² and that productivity is higher in companies hiring knowledge immigrants¹³. Dutch researchers who conducted their postdoc training at prestigious foreign universities performed, for instance, better than those who remained in the Netherlands. The most productive academics, in terms of referred publications, are those with the most international collaboration, including co-publication of articles and publishing in a foreign country¹⁴. Franzoni et al¹⁵ found that migrant scientists in the USA on average perform at higher level than domestic scientists. These scholars explain the superior performance of migrant scientists by the so-called "mover's advantage"; mobility allows them to match their particular knowledge with those of others and to work in places where their specialization is optimally surrounded by complementary resources. They thus concluded that policies to facilitate immigration for high-skilled human capital and policies aimed at harmonizing the international job market for research could be beneficial to science. This evidence would support the policy rationales presented above.

For Europe, recent research¹⁶ revealed that there is great diversity within the academic labour force in terms of research performance. In fact, the top ten percent of "European super elite researchers" produce almost half of the total research output and international orientation and collaboration is the single most important set of variables predicting their high research productivity. From this study, it was concluded that the role of these top performers is bound to increase, with the growth of individualized competitive research funding in many countries. With the growth of individual and portable grants (such as through the European Research Council, see below), a concentration of these high-performing academics in highly ranked-institutions would occur, not only leading to growing national research concentration in selected institutions within individual countries, but in fact that to happen at a European level, leading to an even more uneven distribution of talent in Europe.

The next section will demonstrate and discuss in more detail that the rise in academic mobility occurs especially among young researchers in doctoral training (PhD students) and post-docs. And that in Europe the mobility is mainly intra-European, while in the USA mainly from Asia.

SPECIAL FOCUS ON INTERNATIONAL DOCTORAL STUDENTS AND THE MIGRATION OF POST-DOCS

OECD data¹⁷ reveal that while in OECD countries, the annual number of doctorates awarded grew by nearly 40% in the decade to 2008, in China the number of PhDs awarded grows by around 40% each year. From 1985 to 2005, international students accounted for the bulk of the growth in science and engineering (S&E) doctorates in the United States, and the majority from China. Also in Denmark, Finland, and Ireland the growth of international students seeking a PhD was stronger than the growth of nationals receiving PhDs. Across Scandinavia, the overall number of doctoral degrees awarded grew by 32% between 2002 and 2011, while the number of PhD's awarded to international students increased by 121% in the same period.

Further analyses by the OECD¹⁹ demonstrates that the mobile PhDs constitutes mostly a brain gain for OECD countries. International doctoral students make up more than 20% of enrolments in advanced research programmes in Australia, Belgium, Canada, New Zealand, the United States, and the Nordic countries. And even more than 40% in Switzerland, the United Kingdom, and the Netherlands. It is highly probable that a large proportion of these students are from non-OECD economies.

Analysis of the careers of doctorate holders¹⁹ shows that the labour market for doctorate holders is indeed more internationalised (i.e. a higher share of foreign born) than that of other tertiary-level graduates. For instance, in European countries 15-30% of doctorate holders had worked abroad in the previous ten years. The fact that the percentage is higher among more recent graduates indicates that mobility may be increasing. This seems to refer in particular to the growing international mobility of post-docs.

The United States attracts a particular large number of international doctorate holders, as was indicated above. More precisely, Auriol et al²⁰, found that there were around 610,000 foreign-born doctorate holders in the United States in 2005-2009 representing 27% of the total population of doctorate holders in this country and an increase of 38% compared to 2000. Close to 100,000 doctorate holders were born in China, of which 40% have US citizenship. The equivalent numbers for India were 64,000 and 54%. South Korea the United Kingdom, Germany, Canada and Chinese Taipei each have between 20,000 and 30,000 native born doctoral graduates residing in the United States. However, a variety of indicators, of which the number of visa deliveries, seem to point to a decline in the immigration of foreign scientists and engineers during the recent economic downturn. This is raising concerns about the 'stay rates', especially with respect to the international recipients of doctorates in science and engineering (S&E). Auriol et al²¹ found that recipients of S&E doctoral degrees had higher stay rates than recipients of degrees in disciplines such as economics and other social sciences. Doctoral graduates originating from China, India, Iran, Romania, Russia and the Ukraine also had above-average stay rates.

In order to improve the stay rates, efforts have been undertaken to liberalize visa regulations, to open employment opportunities, permit postgraduate work, easier degree recognition; improvement of cooperation between the universities, governments, and industry; and many other initiatives²². These efforts are quite understandable, as foreign-born employees in the United States represent not only fifteen percent of the work force, but even one third of all engineers, half of the PhD holders in this sector, and over 60% of the PhDs awarded in the natural sciences. They also contribute significantly to the most innovative sectors of the US economy, i.e. to technological innovations and patenting. There is for instance at least one foreign born among the establishers of more than half of the start-up companies in Silicon Valley in the last decade. Of the patents that have been established by the top ten universities in the United States, 76 percent had at least one submitter who was born abroad. One in four Nobel Prizes awarded to Americans between 1990 and 2000 went to a migrant²³. These immigrants clearly represent an incredibly important part of the country's human capital and it is thus clear why the US has an interest in ensuring that they stay.

These issues are also highly relevant for Europe. However, considerably less consistent data are available for this group of countries as a whole. But data for the Nordic countries indicate for instance that more than half (54%) of the foreign PhD graduates in these countries did not stay in the country where they had earned their doctorates²⁴. Below we will take a closer look at the situation in Europe.

But first we turn to the critical debate related to the growing imbalance in global flows of researchers. As stated above, there are a number of push and pull factors that influence doctoral and post-doctoral mobility, and although mobility decisions are often complex, they are also often influenced by the quality of science labour markets in home and potential host countries, as well as of the reputation of host institutions or research groups. Clearly, a particular range of mainly OECD countries is very successful in attracting talent from around the world, which allows these countries to further strengthen their R&D capacity and the reputation of their institutions. This seems to result in an even stronger concentration within and consequently more uneven situation between regions.

INTERMEZZO: A CRITICAL DEBATE ON INCREASING GLOBAL IMBALANCES

The increasingly uneven situation obviously raises concern and fuels the ongoing debate on brain drain - brain gain or brain circulation. Altbach²⁵ for instance argues that the flow of international doctoral students represents a subsidy of the developing countries to the west. He states that:

There is wide agreement in Europe and North America that new initiatives to entice the "best and brightest" of professionals from other countries, whom they educate, to stay and join the local labor force are a good idea [...] There is absolutely no recognition of any contradiction between, for example, Millennium Development Goals, which stress the necessity for educational development in the emerging nations and policies aimed at attracting the best brains from developing countries [...] Until universities in developing countries offer the academic culture and facilities that top academics expect—including

academic freedom, unrestricted information access, and laboratories—they will be unable to attract and retain top academic talent, but the policies of the rich countries certainly do not help.

Also the Council of Doctoral Education of the European University Association²⁶ has a critical stance towards the uneven global flows of researchers:

A diverse, worldwide research system has many benefits but it must not result in work being concentrated in a few global hub [...] A more globalised and more diversified research setup will provide more opportunities for research collaborations and will widen the pool of talent. A bigger and more culturally diverse set of researchers can only be a benefit to all.

While others argue that this process should be considered as brain circulation, rather than as a matter of brain drain and brain gain. Gardner²⁷ for instance states that:

Today, migration among elites is increasingly being viewed as a circular process of migrating to and from or on to another country. This is a process that both industrialised and developing countries can benefit from.

Franzoni et al²⁸ support this view on the basis of their research:

Our findings that the positive effects of migration persist having controlled for selection, suggest that brain migration is not a zero-sum gain, in the sense that the benefits that accrue to the destination country do not necessarily come at the expense of the sending country, and that there are conversely positive externalities to be gained by promoting mobile scientists to work with domestic scientists.

Whether or not this process is considered circular, or a zero-sum game, strongly depends on the perspective and aims of the particular stakeholder(s). Most researchers are free to move across borders and many seek to enhance their career opportunities beyond the national system and even globally, with resultant benefits for a relatively small number of countries and institutions. The current geography of global scientific powerhouses and magnets for academic talent may be changing, as a result of newly emerging science capacities and infrastructure in Asia in particular. At the same time, categories such as developed or developing countries have shifted considerably in the last decade, as witnessed by the pressures around the representation of BRICS countries in international organisations such as the IMF and the World Bank. It is clear that the global competition is rising and that international student mobility is increasingly considered a part of a competitive agenda, whereas it was for long, and especially in Europe, mostly considered part of the cooperation paradigm (as analysed by Huisman & Van der Wende²⁹). In many countries and not long ago, status changes of international students were often prohibited, sometimes to protect the domestic workforce against competition, but more often, in particular those from developing countries, to avoid a brain drain. This perspective is changing and new policies have been developed to facilitate the study-to-work transition of international students³⁰.

The next section will discuss the implications of these trends for Europe, where they play out in combination with the severe consequences of the global economic crisis, the resulting European currency crisis, and the demographic trend of an ageing population.

A CLOSER LOOK AT EUROPE: THE QUANTITATIVE DIMENSION

The current European labour market is facing a quite disappointing situation with high unemployment (11% of the labour force in EU27 in 2013) and with particular risks for the youth (23% on average, but with peaks over 50% in the south) and those with low skills³¹. At the same time some two million vacancies remain unfulfilled, mostly in professional, scientific, and technological areas, including 800.000 researchers and 700.000 ICT specialists. After finance and sales professionals, the most frequently reported shortages concern biologists, pharmacologists, medical doctors and related professionals such as nurses, ICT computing professionals and engineers. These mismatches between the supply of skills and the needs of the labour market are stronger in some countries (e.g. Lithuania, Bulgaria, Belgium, Hungary and Ireland) than in others (e.g. Portugal, Denmark and the Netherlands)³². At the same time, students continue to enroll in studies leading to high unemployment fields³³.

Morehouse³⁴ notes that Europe is in a state of transition and paradox: while it has a youth talent surplus in 2013 (the unemployed youth, see above), it will be facing widespread talent shortages in 2030. More than 45 million employees may need to be added by then. Skills shortages and mismatches are thus very real challenges; within a decade there will be a negative balance between supply and demand for talent in at least 12 European countries, among which its largest economies.

The European Commission³⁵ estimates that a net increase of even one million researchers is needed over this decade. While Europe has many talented and skilled researchers, and the total head count exceeds that of the US, Japan and China, they account for a significantly lower share of the labour force than is the case in the US and Japan. The Commission also states that without more researchers and an open labour market for researchers, Europe cannot remain globally competitive. Morehouse, however, argues that enhancing EU-mobility will only be a short-term solution, as the global working-age population will mainly be non-European by 2050. Especially China is expected to be a strong competitor for skills by mid-century.

In Europe, the existing mismatch between supply and demand may further increase as a result of uneven trends. Firstly, Cedefop³⁶ estimates that the demand for high skilled labour will grow between 2010 and 2020 by almost sixteen million. Most projected increases are expected for high-skilled professionals (such as physical science, mathematical and life-science engineers, health and teaching professionals) and technicians and associate professionals (including physical, engineering, life science, health and teaching associate professionals). These two categories are also expected to hold the highest potential for job creation in the next decade (2.7 million and 4.5 million respectively). Also according to Cedefop, this trend is as such paralleled with an increase in the supply of high qualifications as a proportion in the labour force of EU 27 (from 15,6% in 2000 to 26,6% in 2020).

However, further elaboration of Eurostat data³⁷ shows that the picture is more complicated. First, it is important to distinguish between jobs (occupations) and skills (qualifications). For jobs, at aggregate level a pattern of polarization seems to emerge with more jobs being created at upper and lower levels within the traditional hierarchy of jobs, and stagnation or even decrease of new jobs at medium levels. Cedefop³⁸ also acknowledges this trend towards polarization on the labour demand side for Europe (as does the OECD for a wider range of countries). However, on the supply side the trend is towards a linear up-skilling of the population. Depending on the speed of these changes, there is a risk that in some countries a skills mismatch problem will arise or increase. This vertical mismatch can be of two types: over-qualification or unfilled demand.

Second, Cedefop data indicates that although all EU countries will increase the share of high qualifications in their labour force, an uneven distribution will remain in the short- and probably long-term. Those countries with already high levels will likely move further ahead, while others are still catching up from a lower level. Consequently, the vertical mismatch may emerge more in certain countries than in others. As is noted by various scholars³⁹, this creates a risk of an exodus of high-skilled workers from countries where unemployment is high to countries where jobs are available. Such ongoing migration potentially serves as a "brain drain" on countries where investment in R&D is low, concentrating the highly skilled and talented in the countries of Europe with well-developed research infrastructure and high R&D investment levels. This may harm the economic growth of countries losing graduates, while increasing disparities among European countries.

This type of uneven mobility seems to be further enhanced by EU certain measures. Not only may enhancing EU-mobility only be a solution on the short term (as argued above), it also seems to contribute to increasing the disparities between countries. A striking example is the generous and highly competitive grants awarded by the European Research Council (ERC). Teixeira⁴⁰ suggests that they seem to enhance the pattern of winners and losers, as relatively few researchers from central and Eastern Europe and from southern Europe gain these grants. Moreover, those who win are free to take the grants to a location of their choice. As a result, strong countries like the UK, Germany, and Switzerland are boosted further. These conclusions are confirmed by Zecchina⁴¹, who found that country performance in ERC is indeed diverging since its start in 2007, whereby a few countries are big net importers of research talent (notably the UK and Switzerland) or research grant moneys (the UK and the Netherlands). This is of course relative to the outbound mobility of their national researchers (especially Germany and Italy have a lot of nationals who moved elsewhere with their ERC grant) and to the national contribution to the ERC through the EU (here the UK and the Netherlands have the largest surpluses, followed by Sweden, Belgium and Austria, while almost all other countries demonstrate a deficit, with the largest for Italy, followed by Germany, Spain, and France). The above noted phenomenon of the "European super elite researchers" may be expected to become more and more in demand and thus mobile and contributing to these uneven flows and a resulting growing concentration of the minds in Europe.

A CLOSER LOOK AT EUROPE: ILLUSTRATION BY COUNTRY CASE STUDIES

As said before, these mobility trends concur in Europe with movements of individuals driven by the global economic and resulting European currency crisis. The following short country examples⁴² will illustrate this.

- Countries in the **south of Europe** suffer probably from the biggest loss of talent. For instance 73% of individuals leaving Greece now have a postgraduate degree, 51% a PhD, and most have studied abroad in some of the world's best universities. The dominant destinations of current emigrants from Greece are to the UK (31%), US (28%), and Germany. Italy loses many highly skilled too, mainly to the US (34%), UK (26%), and France (11%). The main reasons being a lack of research funding and better economic conditions and career opportunities abroad. In Spain, many foreign PhD holders

seem to move elsewhere, as it is difficult for them to integrate into the academic working force due to inbreeding, job advertisement in Spanish, etc.

- A study carried out in **central and eastern European countries** by the Economic and Social Research Council⁴³ found that the majority of respondents wanted to do good science and to be able to work effectively in their chosen field. However, for science research areas requiring large or expensive equipment, doctoral candidates often face a lack of opportunity for practical work in their home country. So many sought to move because of poor working conditions in their home countries and better conditions abroad. Even short-term mobility is attractive in terms of contacts with devoted researchers from abroad and with modern equipment as well as the prospect of some better payment in terms of fellowships during scientific visits. It was even said that Bulgarian salaries of young scientists in higher education and research cannot attract any gifted and bright students.
- The disparities are not necessarily regionally clustered, as is demonstrated for instance by the **UK and Ireland**, the former being a big net importer of talent and research funds (see above), while the latter has lost a great number of its highly educated work force over the last years. Here the divers impact of the economic and currency crisis has played a role.
- But also specific national policies may have a different impact, as is demonstrated in the **Nordic countries**. Although these are economically strong countries (and not severely affected by the crisis), with the highest GDP percentages investment in R&D in Europe, more than half (54%) of the foreign PhD graduates in the Nordic countries do not stay. And although the Nordic countries have well-connected science systems, the scientific mobility patterns seem to vary here to some extent.

Sweden was steadily increasing its share of foreign students, which make now up for 40% of all people starting a PhD and even 60% in STEM fields. But concerns about a decrease in these numbers are due to the recent introduction of tuition fees for students from outside Europe.

In Denmark, universities are increasingly delivering highly qualified personnel to other countries, becoming a net exporter of PhDs. Addressing these concerns, recently a broad governmental initiative was launched to attract highly qualified workers to the country with tax benefits, fast-track employment, simplified immigration measures. International PhD and masters students from outside the EU are attracted and retain with tuition fee exemptions and study grants and a general boost on the internationalization of Danish higher education. One result is an increase of 11% of international degree students between 2011 and 2012⁴⁴.

Finland is also strongly internationalizing its research career system, at the same time seeking placements abroad for PhD graduates and recruiting senior researchers from abroad. Both are considered vital for increasing the attractiveness of research careers in this small economy.

Norway is an even more special case. It recruits foreign doctoral students for programmes with a contractual obligation to return to the home countries (no perspective to stay). Training them without charging high tuition fees is considered by the government as a "pay-back" for the thousands of Norwegian students who studied abroad in previous periods. Yet Norwegian industry relies on foreign graduates to fill many of its job vacancies, especially for positions in energy research. Universities feel that as long as applicants from Norway can enter the sector directly with an MSc degree and until industry recognizes the importance of a PhD by providing extra incentives, they will not be able to recruit the most talented Norwegian MSc candidates for a doctorate.

- Finally, two small countries in different parts of Europe and with very different geographies: **Switzerland and the Netherlands**. Both demonstrate very strong research records (in the global top 3 producers of research) and importers profiles. In Switzerland, the percentage of international PhDs students more than doubled (from 25% to nearly 52% in 2012) over the last two decades. In the same period the absolute number of all PhD also almost doubled (from 11,588 in 1992 to 22,716). 76% of the foreigners are European, with about half of them coming from neighbouring countries such as Germany, France and Italy. The country's multilingualism is seen to help to attract foreign students and staff, who have a particularly strong representation in STEM fields. Immigration rules are key for these small and very open countries with a high level of scientific activity. In this respect the February 2014 referendum on immigration in Switzerland obviously raised great concerns among the leading research and science centres, since the international dimension of Swiss research has been such an important factor in its success so far.

The EU's almost immediate response by excluding the country from the Erasmus+ and Horizon 2020 programmes confirmed the seriousness of the issue. Switzerland will have to finance its participation in these programmes for both

outgoing and incoming student mobility and also negotiations for research mobility and cooperation are put on hold. Besides the short-term uncertainty for students, this raises severe concerns about the long-term impact on research.

In the Netherlands the percentage of international PhD's (as employed by the universities) increased over the last few years from 35% in 2006 to 45% in 2010. 60% of them are from Europe, 25% from Asia and Oceania, and 10% from North America. They are particularly well represented in the STEM fields, making up for more than 50% of all PhDs at technical universities. By attracting so many, the country is in part compensating for low domestic interest in STEM fields and a loss of brains to the US, the UK, and presumably Germany where investments in R&D have been much stronger over the last years. The Netherlands is perceived to have a most liberal immigration policy for knowledge workers, despite the rise of xenophobia from the political developments of the last decade. Yet, criticisms arose over the criteria for the immigration of knowledge workers related to the ranking position of the universities where they obtained their graduate degree and on particular restrictions that were set on access to nuclear research facilities (for Iranian PhD students for instance).

In a recent report to the Dutch government, the Netherlands Scientific Council for Government Policy (WRR)⁴⁵ suggested further steps towards "a learning economy". It is argued that as a small and open economy, the Netherlands receives greater benefits from external rather than from domestic R&D and could thus choose to become a "knowledge importer", specializing rather in applying knowledge produced elsewhere, than primarily doing so itself. It stresses the concept of knowledge as a global public good, although no "free riding" would be envisaged. Instead it would require a great absorption capacity and a focus on the importance of more dynamic knowledge infrastructure and networks. Conditions would heavily draw on stronger education paradigms, including innovative practices in higher education. Although implementation is so far unclear, there may be some similarity with the rationales underpinning Norway's choice to decrease fundamental research.

From this mostly quantitative analysis of research mobility in Europe, it seems that the traditional intercontinental mobility patterns, i.e. from the south to the north and the east to the west, are now paralleled within Europe. And also that the disparities between countries in terms of R&D investment and skills imbalances increase as a result of both the global economic crisis and certain EU measures. Consequently, the European open labour market for research with envisaged brain circulation may easily turn into a brain drain – brain gain situation. This raises a set of policy questions for Europe. But before discussing them, some light should be shed on the qualitative dimensions of the skills needed for research and innovation in Europe.

A CLOSER LOOK AT EUROPE: THE QUALITATIVE DIMENSION

In July 2013, the EU ministers responsible for research and innovation gathered for an informal meeting under the Lithuanian presidency. Their discussion focused on the question what skills are needed for science and innovation in the 21st century, inspired by the proposed large budgets for the sector (80 billion Euros under the Horizon 2020 initiative) eventually agreed by the European Parliament. The insights presented by experts (the author among them) revealed that skills mapping is a complex matter in general and even more so for research and innovation in particular. Not at least as this concerns by and large skills for future jobs that still have to be discovered and created.

European reports analyze that methodological and data issues complicate the modeling of skills demands. They require better and more detailed data than presently available at pan-European level⁴⁶. Forecasting skills need is further complicated by the fact that the views of employers' and employees' representatives widely differ, as do those of scientific experts. Although the overall expectation of a future skill shortage is now almost common sense, its size and especially its structure remain much contested and uncertain. Even the increase in higher education qualifications as a solution on the supply side is contested, as it is said that the crucial skills (such as soft and personal skills, see below) are basically acquired at early age and school levels⁴⁷. Moreover, the relationship between educational mismatches and mismatches in acquired and required skills for the labour market seems to differ remarkably per country. It is also widely agreed that globalization and technological change are major driving forces, but there is discussion about how exactly and what it means. There are for instance both trends of outsourcing from and re-shoring of industrial R&D activities to Europe, diverging views on the importance of manufacturing for Europe, and on the question whether ICT replaces or rather creates jobs. Demography remains a major predictor, but the impact of recent (crisis-related) patterns in birth rates is still unclear and also whether the greatly under-exploited female potential for research and innovation can be activated more effectively.

Skills mapping for research and innovation is even more complicated, as analyzed by the OECD⁴⁸. First of all the definitions of both skills and innovation are rather broad. Innovation can, for instance, be understood on a range from science-based discovery to more simple adoption of existing innovations. Secondly there is the difficulty of measuring human capital and innovation outputs and outcomes. Empirically, some loose links between skills and innovation have been detected, leading to only very general insights. Also the required levels of attainment (e.g. technical qualifications or advanced research degrees) are not

always clear. Consequently, cautions against simple "more-is-better" policy prescriptions are justified. Instead, policies to encourage skills for innovation and research may need to be broad, as a mix of many different skills seems to be relevant.

The broad mix of skills needed in innovative societies and sectors have been described in terms of eight key competences by the European Commission⁴⁹ and categorized in broader clusters by for instance Trilling & Fadel⁵⁰ and the OECD⁵¹. Besides the more traditional skills, i.e. basic skills (literacy and numeracy), academic skills (associated with subject matter areas), and technical skills (knowledge of certain tools and processes, usually specific for an occupation), there is increasingly strong focus on the so-called "21st century skills". These may refer to generic and soft (personal) skills in areas such as problem solving, thinking critically and creatively, ability to learn and to manage complexity, work in multidisciplinary teams, communicating across cultures, foreign languages, "digital-age literacy" skills - ICT literacy, creativity and design skills, leadership, managerial and entrepreneurial skills, team building and steering, coaching and mentoring, lobbying and negotiating, co-ordination, ethics, charisma, etc. etc.

This is a very broad, and still to some extent ambiguous, set of skills indeed and it may be difficult to pinpoint the essential features. Employers seem to like all categories almost equally⁵², indicating that they may (still) be looking for the perfect all-rounder. However, Avvisati et al⁵³ argue on the basis both employer and employee data from relevant sectors, that there may not be one ideal type of graduate or employee, but that innovation is in fact served by contributions from a wide range of disciplinary backgrounds and suggest that fostering skills for innovation could (thus) be an objective of any higher education programme. They generally call for a broader focus of innovation policies, then those traditionally limited to science and engineering graduates, although their data also demonstrate that those are still among the most likely to have a highly innovative job.

The most important aspect of these discussions seems to be the growing understanding and recognition of both the traditional and the 21st century skills instead of a polarized either-or debate. And more precisely to acknowledge the particular virtue of graduate profiles that combine strong STEM skills with 21st century (or soft) skills at the same time. As an ideal mix, this cannot be claimed to be really novel, however, as it goes back to C.P. Snow's⁵⁴ plea in the late fifties to overcome the gap between the humanities and the sciences and even long before that to the liberal arts model including both the literary and the mathematical arts. This model was at the origin of the European university and has a renewed value and strong potential for the 21st century, as is already demonstrated in some particular initiatives in Europe⁵⁵.

These include examples such as the Dutch university colleges and other innovative liberal arts and science initiatives in Europe, as well as other efforts for interdisciplinary training. However, it is still only a minority of higher education programmes and institutions that provide for the combined training of this skills mix, due to the mostly rigid disciplinary structure of the European universities.

CONCLUSIONS, POLICY QUESTIONS AND IMPLICATIONS

The global competition and international academic mobility in science and research is rising. Within this context, Europe faces quantitative skills shortages, including an estimate of between 800,000 and one million researchers. Within Europe skills imbalances and mismatches increase, with a growing divergence between countries and regions, in particular between the North and South, in terms of their ability to invest and attract human and financial capital for R&D. As a result intra-European mobility is not only on the rise, but may easily turn from an intended brain circulation into a brain drain – brain gain situation. From a qualitative perspective solutions to the skills shortages and imbalances relevant to science and innovation require the training of a broad mix of skills, which currently provided to only in a minority of students in European higher education institutions and programmes.

Will the intra-European flows of human and financial capital for R&D result in a further concentration of the minds in a limited number of regions or hubs in Europe? Is this (un)avoidable or (un)desirable? The further concentration of talent appears to be Europe's fate. These forces play out quite differently across the various disciplinary fields. In general the "STEM fields" (including engineering, natural, life and medical sciences) are already most internationalized and especially their experimental branches require the highest concentration of financial and human resources for large-scale and high-tech research infrastructure. Consequently, research in these fields will most likely become even more concentrated in a limited number of European centers or hubs, such as CERN or a possible EIT 2.0 model. Research in the social sciences and humanities is likely to remain more distributed and can stay more rooted in the national context, while being increasingly networked at European and international levels.

Such a development can be seen as a further move towards the required critical mass and efficiencies of scale. In all, an efficient macro-level solution and effective European-level response to global competition, i.e. strengthened European cooperation for enhanced global competitiveness. In that sense one could argue that the open European labour market is actually functioning

for researchers as intended in its outset, by offering them better career opportunities. That European-level competitiveness is on the rise and that a positive impact on the quality of research can be expected on the basis of the "mover's advantage" i.e. the above average performance of migrant scientist, as evidenced in the USA (see above). But it may also mean "European super elite researchers" will become more concentrated in highly ranked-institutions across Europe, which would enhance the global competitive position of these institutions, but also the recognition of increasing diversity within Europe in terms of performance of institutions and countries. It would also mean a shift from the traditional European cooperation paradigm (as described by Huisman & van der Wende⁵⁶) to the competition paradigm, including accepting the latter also as an internal European logic and reality.

The acceptance of geographical concentration of science and research in Europe cannot only be analyzed from an economic perspective. Or from the point of view of the European Union as a free market of minds, since it will also imply a concentration of minds in social and cultural terms. As argued by Corbett⁵⁷, the situation in Europe as a collection of states is more complex in any assessment of national as opposed to collective European benefits. Therefore, the social and cultural conditions and impact should also be taken into account. It can be argued that the increased scientific mobility provides opportunities for further integration, cultural exchange and understanding for those involved. But there is a broader interest for these objectives, i.e. beyond the mobile elite, and therefore important to preserve the universities' social-cultural role and meaning both in the national and European context. This certainly belongs to their mission, in particular to their teaching mission, but it should be acknowledged that this concentration puts the classical model of the comprehensive European university under pressure.

As argued above, the current combination of mobility and funding flows and trends seems to cause an increasing concentration of especially high-tech research capacity (in the natural and life sciences) in a limited number of regional hubs, which is likely to the detriment of the broad comprehensive profile of universities in certain weaker regions and countries. Those institutions may have to choose more specialized profiles, focusing more on less (human and financial) capital-intensive fields in the social sciences and the humanities. This may be in line with what has been discussed extensively in the higher education literature (by Clark Kerr, Bob Clark and others), i.e. that the comprehensive university model is not fit for all contexts and that specialized universities are likely to find change easier than comprehensive ones. This may not only lead to less comprehensive profiles, but also urge a rethinking of how to sustain the Humboldtian values around the teaching-research nexus in various fields and at the different levels.

In any case, the on-going Bologna process and the future higher education agenda in Europe will be enriched by recognizing the need for more differentiation. From generally enhancing the basis by innovating the undergraduate level, allowing for the training in a broad mix of skills, followed by more selective pathways to graduate research degrees, with continued attention for interdisciplinary approaches and generic and transferable skills up to the level of doctoral education. Also in this respect, the traditional European model of the university, with its overly disciplinary fragmentation, often reflected not only in internal structures, but also in its incompatible professional and academic cultures, is being challenged. New avenues will require strong leadership, revised governance structures, and enhanced institutional autonomy.

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