The Brain Drain of Ph.D.s from Europe to the United States: What We Know and What We Would Like to Know

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The growing role of universities in the ‘knowledge economy’ is well known. A dynamic and well-balanced academic system is a key engine of innovation and economic development. Doubts persist however as to whether Europe’s universities are fully capable of fulfilling that role. The members of the Forum approached these issues by focusing on the following research themes: (1) Universities and the changing dynamics of knowledge production; (2) Patterns of the division of labour in research and innovation system; (3) The internal organisation of academic systems: tensions and adaptations; and (4) Diversity, innovativeness, and the governance of academic systems.

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Abstract

In this paper we discuss the widely acknowledged so-called ‘European brain drain’. We find that there is an asymmetry in the flows of Ph.D. students and post-doctorate researchers between Europe and the United States, to the advantage of the latter. However, we point out that this conclusion is based on incomplete and imperfect data, particularly at the post-doctoral level. This does not allow us to draw any definitive conclusion on the European brain-drain question. We argue that, in the context of increasingly knowledge-based economies, brain drain is a complex question as the current situation tends to imply many types of return, circulation and recirculation of the highly educated. We identify three main unsolved issues. Firstly, few things are known on the return migration of European Ph.D.s. Secondly, the net balances in the brain-gain and brain-loss have to be placed in relation to the stock of Ph.D.s. Thirdly, uncertainty remains about the ‘quality’ of Ph.D.s who ‘circulate’. We argue that a correct assessment of the European brain drain would have to seriously consider these issues and would require a European statistical information system on Ph.D. mobility.

Keywords

brain drain, migration, scientists, globalization, knowledge-based economy

JEL classification: F22, J61, O15
Introduction

International migration is not a recent phenomenon. Historically, the first wave of globalization, that took place during the period between 1870 and 1913, involved substantial international mobility (Hatton and Williamson 1998). International mobility of scientists also has a long tradition as science is, by nature, a universal culture. Without going back to scientific mobility between Athens and Alexandria, the academic labour market has been international for a long time. Fortney (1972, p. 51) in a description of the historical inflow of scientists to the United States, noted that, between 1900 and 1930, a small, but not negligible proportion of immigrants were professional. From 1930 to 1941 however, ‘the truly amazing phenomenon that occurred […] was the number and the prominence of the scientists and scholars who emigrated.’

The brain drain debate emerged in the post-war period and was actively debated in the 1960s. At that time, the United Kingdom, as well as Canada, feared a deficit of scientists and engineers mainly attributed to the brain drain (Godin, 2002). In the 1950s, in the United States, there were important debates on shortages of scientists and engineers but the brain drain issue was nonexistent in this country because the United States has been a net importer of scientists and engineers. The situation was different in Europe as the brain drain was considered to be the source of shortages in scientists and engineers.1 Two views dominated the positions during the 1960s, the internationalist view and the nationalist view. They were expressed in a 1968 debate by two prominent economists, Harry Johnson and Don Patinkin (Adams 1968, Elleman 2005). The brain drain has been a major concern for developing countries and its consequences have been extensively studied from the 1960s onward.

Recently, there was a revival in the brain drain question. This revival may be attributed to skill shortages resulting from skill-biased technical change, educational failures or increased international competition for access to skills and competencies (Commander et al. 2002). The conditions that govern mobility have changed in light of new forms of communication, transportation, geopolitics, intercultural relationships and commerce. The brain drain is questioned in new terms as competition for talent increases among developed countries and as more countries, notably in South East Asia and Eastern Europe are becoming increasingly knowledge-based economies. Highly skilled personnel might stop flowing out from those countries (Mahroum 2000). The brain drain question is thus more complex than the simple South-North flow of highly qualified people. It might be going in all directions, north-north, north-south, south-north and south-south. The migration may be temporary rather than permanent and multi-directional instead of unilateral. It seems to be a global movement (Meyer 2003). In order to reflect the complexity of the phenomenon, a new concept has been introduced namely, the ‘brain circulation’, which refers to the cycle of moving abroad to study, then taking a job there, and later returning home to take advantage of a good opportunity (Gaillard and Gaillard 1998, Johnson and Regets 1998, Saxenian 2000, 2002a, b). Actually, traditional brain drain co-exists with brain circulation. The form of mobility implied by brain circulation, which is often perceived as positive, as it generates knowledge transfers, is supplementary rather than opposite to brain drain. Indeed, countries might win or lose from scientific migration depending on the length and nature of the mobility (Casey et al. 2001). Indeed, in the knowledge-based economy where the drivers of growth are exchanges of ideas, knowledge creation and innovation, the international mobility of researchers may have positive effects on knowledge creation.

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1 According to Johnson (1965), the term brain drain originated in the UK with the British Royal Society. See also De Chadarevian (2002) and Godin (2002).
In the context of the international competition for knowledge in science and technology, the EC adopted an ambitious target at the Barcelona Council in 2002: research and technological development (R&D) investment in the EU must be increased with the aim of approaching 3% of GDP by 2010, up from 1.9% in 2000 (European Commission 2002). A complementary objective is to increase the level of business funding, which should rise from its current level of 56% to two-thirds of total R&D investment, a proportion already achieved in the United States and in some European countries.

The question is thus how to reach the 3% objective. According to the Brussels Commission, available data show that lack of human resources is a major constraint on the EU’s capacity to deliver on the 3% objective, even though Community policies already recognise the importance of having sufficient numbers of research scientists and engineers with appropriate qualifications. Indeed, the increased investment in research will raise the demand for researchers. It is estimated that ‘human resources growth associated with this target is of the order of [...] about half a million extra researchers.’ (HLG 2004, p. 4)2.

The EC and most of the European countries thus fear a shortage of scientists and engineers that may have harmful consequences, in the long run, on the advancement of the knowledge society. This threat is amplified in many European countries by the decrease in enrolments in many science disciplines, the aging of researchers in the public sector and the migration of EU researchers to other parts of the world, mainly to the United States. Therefore, the migration of scientists and engineers is a critical issue in a global knowledge-based economy increasingly relying on science and technology skills.

In this article we would like to discuss the widely accepted so-called ‘European brain drain’. Indeed, the European situation may be more complex than the one-way, definitive and permanent migration of scientists from Europe to other parts of the world, mainly North America, which is traditionally implied by this expression ‘brain drain’.

We will focus on the international mobility of Ph.D.s. Three main arguments can be advanced to justify the choice of this target group:

i. The issue of international mobility of highly skilled personnel is complex and diverse. Each group of highly skilled professionals is pulled and pushed by different factors and requires diversified policies (Mahroum 2000). A global analysis of the brain drain would be very interesting but is also highly ambitious. It would be extremely difficult to map skilled international migrations on a global scale as there is no international system for recording skilled emigration. Two studies attempted to do so by combining different statistical databases. Carrington and Detragiache (1998, 1999) provided the first estimates of emigration rates at the tertiary level for numerous developing countries. Docquier and Marfouk (2004) have expanded the number of countries covered by the database to the majority of OECD countries and to a larger number of developing countries, and have refined the quality of the estimates. However, these studies suffer from the lack of harmonized international data on migration by country of origin and education level.

ii. Ph.D.s are crucial to the conduct of research and innovation in national innovation systems. In the knowledge economy they provide a large amount of input into creating the competitive advantage notably through basic research. In that respect, the question may be less in terms of quantity rather than in terms of quality. Indeed, small numbers of migrants among Ph.D.s may not be without importance if migrants are ‘star scientists’ or the most productive or innovative researchers. This may have long term consequences on economic growth, particularly if there are strong spillover effects as

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2 However, this statement qualified a previous widely advertised assertion: ‘about 1.2 million additional research personnel, including 700,000 additional researchers, are deemed necessary to attain the objective, on top of the expected replacement of the ageing workforce in research.’ (European Commission 2003b, p. 11)
the ‘new growth’ theories predict. The mobility of Ph.D.s may be affected by job opportunities, research funding, quality of research environment and research training, and research policies. The capacity of a country to attract international talents may indicate the strengths and the weaknesses in its national innovation system, the role of particular institutional arrangements or good macroeconomic policy practice. Ph.D.s also play an important role in education (of students) and research training (of young researchers) as well as in the diffusion of knowledge in society.

iii. The international mobility is traditionally particularly high among Ph.D.s. The share of foreign students is greater in all countries at doctorate level than at the undergraduate stage of tertiary education (OECD 2002). Historically, academic and scientific networks have played an important role in the advancement of science. Indeed, the diffusion of scientific ideas requires geographic mobility, and notably international mobility, as a great part of knowledge is tacit and requires face to face contacts for its transfer. However, new forms of international migration might emerge and have to be identified.

The paper is organised as follows:

In a first section we discuss the brain drain question in the context of increasingly knowledge-based economies, with a review of the theoretical literature. We show that the simple unidirectional model of migration has to be replaced by a more complex multi-directional and multilateral model. Indeed, the progressing globalisation of the scientific labour market tends to imply many types of return, circulation and recirculation of brains. In order to reflect the complexity of the phenomenon, the concept of brain circulation is introduced.

In a second section, we try to establish the net balance sheet on exchange of Ph.D.s and post-docs between Europe and the United States. It appears that the flow of Ph.D. students and post-doctorates from Europe to the United States is higher than the corresponding flow from the United States to Europe. However, this analysis does not allow us to draw any strong conclusion on the European brain drain question as a number of issues remain unsolved.

In a third and final section, we argue that we need to know more on three main issues. First, the return migration of European Ph.D. students and post-doctorates have to be taken into account. Second, the net balances in the brain-gain and brain-loss have to be considered and placed in relation to the stock of Ph.D.s in different countries. Third, it would be useful to have information on the ‘quality’ of Ph.D. students and post-doctorates. Finally, we will recommend the creation of a European statistical information system on Ph.D.s, an essential tool for the implementation and benchmarking of the progress towards the European Research Area.

1. Brain drain and brain circulation in the knowledge-based economy: theoretical perspectives

According to the Encyclopaedia Britannica brain drain is ‘the departure of educated or professional people from one country, economic sector, or field for another usually for better pay or living conditions.’ In this section, we discuss some issues related to brain drain according to the (mainly theoretical) literature.

First, we present the main determinants of migrations. Second, we wonder what the impact of the migration of the highly-skilled on receiving and sending countries is.

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3 Fischer (1996, p.33) found that ‘mobility grants for scientists across the Atlantic have done more for the deployment of the new physics in the United States than the same amount of money spent for the acquisition of scientific literature’, cited in Mahroum (2000).
1.1. What are the main determinants of migration?

Many factors influence international migration but some may be more relevant for unskilled people than for highly-skilled migrants, particularly in the context of increasingly knowledge-based economies. The traditional push-pull framework identifies a number of factors affecting international migration. However, some specific elements related to the structure of national innovation systems might be more relevant for understanding the international mobility of scientists in particular.

The push-pull general framework

A push-pull framework is traditionally used by researchers to study international migrations (Cheng and Yang 1998). The outflow of human capital is not only led by better opportunities for study and work in the receiving countries (pulling factors) but also by economic and political conditions at home (pushing factors). On the one hand, favourable conditions in the receiving country, such as high salaries, high living standards, good work conditions and career opportunities, pull migrants to the receiving country. On the other hand, unfavourable conditions in the sending country push the highly qualified people to leave.

We can isolate a few traditional factors that affect the decision to move:4

Expected income differences (adjusted by the cost of emigration, pecuniary and non pecuniary) between home and destination country are classical factors affecting the decision to move. Historically, international differentials in real wages were a main determinant of the age of ‘European mass migration’ from Europe to the USA, Canada, Australia, Argentina, New Zealand in the second half of the 19th century and early 20th century (Hatton and Williamson 1998, 2002). Ideally, the costs of migration should take into account the costs of travelling, the search for a job, the psychological stress caused by differences in culture and language, as well as the social networks (of relatives, friends and peers). The relative rewards for skills may also play a role in explaining international migration according to the self-selection model (Borjas, 1987, 1994). Skilled workers may be more willing to migrate when the host country offers higher relative rewards for skills than their home country.

Labour market conditions are also essential in understanding international migrations. The quality of work, labour market supply and demand signals (rigidity in the labour market would be a negative factor), shortage of skilled labour in some specific fields… certainly play a role. In that respect, the development of knowledge societies, which substitutes unskilled for skilled labour and thus increases the demand for highly qualified people (professionals, IT specialists…), may explain part of the recent increase in the international migration.

Immigration incentive policies also play a role in encouraging immigration. Indeed, according to Mahroum (1999b), immigration legislation remains very important in the international mobility of the highly skilled. Special legislation favourable to skilled immigrants are likely to allow countries to benefit from a growing international pool of highly qualified human resources.

In addition to immigration legislation, other factors, such as taxation, openness in communication, business expansion overseas, safety, political determinants (individual rights and freedom), are other important factors in the choice of migrants to relocate.

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4 Different studies by the ILO (notably in its collection International Migration Papers) and by the OECD have underlined some of them (see for example OECD 2002).
A specific framework for researchers: the structure of national innovation systems and the agglomeration effects

The decision to emigrate for scientists and researchers may be influenced by some specific factors related to the general structure of national innovation systems, and more precisely, to the cumulative nature of knowledge production and the induced agglomeration effects (besides the standard factors listed below)⁵.

National innovation systems play an important role in shaping the international flows of scientists. The quality of research infrastructures, the financial support for academic research, research policies favourable to the development of R&D, or the reputation of universities or public labs, are some factors affecting the decision to migrate. High salaries, good opportunities for high-tech entrepreneurship, employment opportunities in innovative sectors, the perspective of having a successful scientific career⁶, are other factors outlined by the literature (Mahroum 1999b, c, 2000; Technopolis Group 2001).

The scientific strengths of countries are crucial factors in explaining the international migration of talents. A specific country may be a magnet in a particular discipline. In Europe, for example, the United Kingdom seems to be attractive for foreign researchers in clinical medicine and life sciences (Mahroum 2000).

The private sector may also play a role in attracting foreign talents. The quality of research staff, working conditions and wages in the private sector are important factors. However, even in the private sector, reputation may have an influence on the decision to move. McMillan and Deeds (1998) showed for example that the reputation of scientific openness (usually resulting in publication) is an important quality for firms wishing to recruit the best scientists.

However, agglomeration effects and the existence of ‘knowledge intensive clusters’ may be crucial in explaining the international mobility of scientists in the context of increasingly knowledge-based economies. Indeed, international migration of scientists and researchers is highly concentrated in some specific knowledge-intensive clusters. The Universities of Cambridge and Oxford alone received some 15% of all foreign academics employed in the country between 1994 and 1997 (Mahroum, 1999a). One-third of German scholars employed in the United States were located on the West Coast, with 28% in the academic centres of gravity in California (Mahroum 2000 citing a study by CRIS 2001). In 2001, according to NSF data, Harvard University had the most post-docs at 3,597 (followed by Stanford University at 1,210 and Johns Hopkins University at 1,159).⁷ The reputation of excellence and quality in research is enhanced by the presence of star scientists. Top researchers and Nobel prize winners are concentrated in a few prestigious and large universities or public research organisations (MIT, Stanford, Berkeley in the United States). Their presence is a strong magnet for scientists and researchers worldwide.⁸ Indeed, the cumulative nature of knowledge production explains, in the end, this agglomeration pattern. The possibility of acquiring knowledge and first class education/research training, the possibility of interacting with internationally-recognized peers, the international reputation and prestige of an institution, can be some of the inter-related factors explaining the international mobility of scientists.

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⁵ Some of these mechanisms have been outlined by Mahroum (1999).

⁶ The personal aspiration or scientific curiosity may also be of importance.

⁷ Also, University of Pennsylvania 950, University of California, San Diego 949, University of Washington, Seattle 938, University of California, Berkeley 898, University of California, Los Angeles 847 and MIT 828.

⁸ Mahroum (2000) note that Germany played the same role as centre of excellence in physics and chemistry up to the early 20th century.
1.2. What is the impact of high skilled migrants on sending and receiving countries?

There are decades of economic literature evaluating the development and global effects of the emigration of human capital. This literature is almost exclusively theoretical. We present a brief history of the main models of migration of human capital and their results.

The neoclassical growth models of the 1960s: ‘laissez passer…’

The first neoclassical growth models with human capital as a factor of production (Johnson 1967, Grubel and Scott 1966, Berry and Soligo 1969) rely on a number of strong (classical) hypotheses: perfect competition, perfect information, perfect wage flexibility, and aworld without barriers. All markets are clearing and wages are equal to marginal product and there are no externalities. For small numbers of the highly skilled, emigration would leave the economic welfare of the remaining population unaffected. There is no welfare impact on those left behind, as long as domestic wages did not rise as a result of the shift in labour supply (Commander et al. 2002). Individuals should be expected to migrate from places where their productivity and income is lower, to places where their productivity is higher. In other words, human capital will go from countries with lower returns to countries with higher returns. The world income should be higher with mobile human capital and marginal productivity will tend to equalize. The policy conclusion of Grubel and Scott is thus clear: laissez passer. Johnson (1967), however, points out that the effect actually depends on how much capital the emigrants take with them (Commander et al. 2002).

From the 1970s to the 1990s: a brain drain with negative consequences on sending countries

Bhagwati and Hamada (1974), Bhagwati and Rodriguez 1975) were the first9 worried about the possible effects that human capital migrations could exert on welfare and growth in the source economy. They worked with a general equilibrium framework and emphasized on the welfare implications of skilled migration for those who were left behind10 and, ultimately, for the sending country. They introduced two sets of distortions, the first related to the wage setting and the second to the financing of education. They showed that the brain drain might have harmful consequences for developing countries. They derived policy conclusions in terms of the possibilities to tax brain drain.11 Other possible losses, apart from the loss of fiscal revenues, for sending countries, include the loss of initial educational investments or the increasing weakness of the science sector as consequences of departures of qualified workers and scientists.

More recently, a first wave of endogenous growth models also suggested that emigration of highly-qualified people can generate economic losses for the sending country (Miyagiwa 1991, Haque and Kim 1995, Walz 1995, Reichlin and Rustichini 1999 and Wong and Yip 1999). In these models, as in the canonical models of endogenous growth (Romer 1986, 1990, Lucas 1988), there are increasing returns in knowledge (the productivity of human capital depends positively on the availability of human capital)12. High skills emigrants are indeed individuals with a large endowment of knowledge, such that they generate important positive externalities. The first effect of emigration is unambiguously to reduce human capital. There might be a loss of welfare for the remaining population

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9 In the 1960s and 1970s, there was however an extensive discussion not only among academics but also among United Nations agencies on the consequences of migrations from the developing countries to the developed world.

10 Many empirical studies also analysed the impacts of migrations on the labour market of receiving countries (employment and wages of natives). Some recent pieces of literature are Venuturini and Villosio (2003), Bauer and Zimmerman (1999), Straubhar and Wolburg (1998), Wolburg (2001).

11 See Commander et al. (2002) for more details on these models.

12 This idea that average level of human capital in a society has positive effects on productivity and growth seems to be supported empirically (Barro and Sala-i-Martin 1995, Topel 1999).
because of externalities due to a loss of scarce skills. The brain drain has, without doubt, negative effects on growth and implies diverging growth trajectories between rich and poor countries. These first endogenous growth models of high-skilled emigration thus support the expectation that reductions in the average level of human capital slow economic development. This is in contrast to receiving countries which may benefit from increased knowledge gains from highly skilled immigrants as positive technological externalities of immigration arise by the additional human capital that is available to the host economy.\footnote{Solimano (2003, p. 16) sums up these conclusions like this: ‘Matching, complementarities and increasing returns are thus an essential part of the story of emigration of human capital. As the literature on growth and development emphasizes this can lead to virtuous circles and also to poverty traps.’ The theoretical arguments go back to the development literature of the 1950’s (Hirschman, Myrdal, Perroux, Wallerstein divergence or vicious circle or core-periphery view). See also Straubhaar (2000).}

The 1990s and beyond: a ‘beneficial brain drain’?

However, a second wave of endogenous growth models has introduced the notion of beneficial brain drain even for sending countries (Mountford 1997, Vidal 1998, Stark, Helmenstein and Prskawetz 1997, Beine et al. 2001, Stark and Wang 2002, Hemmi 2005). In all these models, emigration has a negative direct effect by draining skilled labour out of the sending economy (drain effect) and a beneficial effect in encouraging human capital formation (brain effect). Mountford (1997) put forward the idea of a beneficial brain drain via the incentives for education. People may choose to educate themselves more in order to become eligible for migration, and then to have access to the higher returns of the foreign labour market. He criticised the result established by Haque and Kim (1995) who argued that under standard assumptions on the human capital accumulation function, a brain drain always reduces per-capita income. Mountford (1997) showed that, if not all skilled workers are allowed to migrate, the incentive effect linked to the higher wages available abroad may foster human capital accumulation in the source country and may offset the negative effect of the departure of skilled workers.

Beine et al. (2001) rationalised these results in a model underlying the drain effect suggested by Haque and Kim (1995) and the brain effect suggested by Mountford (1997). The gains in total human capital formation produced by these incentives may outweigh the human capital loss represented by the actual brain drain. Thus, a brain drain might even be good for growth and welfare in the sending economy.

Recently, Mariani (2004) has developed a model which borrows some characteristics of Mountford (1997) and Beine et al. (2001). He concludes that in the short term, emigration is likely to encourage human capital formation only if human capital is quite equally distributed. In the long term, however, this incentive gets dispersed ‘while the human capital flight lasts forever, depressing average income.’ Schiff (2005) also argues against the ‘new brain drain’ literature saying that ‘these claims are exaggerated’. He finds that ‘the impact of the brain drain on welfare and growth is likely to be significantly smaller, and the likelihood of a negative impact on welfare and growth significantly greater than reported in that literature, […] because various negative effects of the brain gain on human capital, welfare and growth have not been taken into account’ (Schiff 2005, p. 3-4).

Other benefits of greater international mobility (other than the education incentives mentioned above) have been underlined by recent studies (Commander et al. 2002). Emigrants may provide essential inputs to new businesses and activities in their home countries (through networks or remittances). They may also provide a flow of information and knowledge. Advances in communication technologies may also change the nature of mobility limiting the extent to which skills are actually lost. Migrants may also return to their home country bringing with them the knowledge they have accumulated. The drivers of growth and development in the knowledge-based economy are such exchanges of ideas, knowledge creation and innovation. Therefore, international mobility is
valuable as it may increase the knowledge at home if there are return migration or knowledge exchanges with the home country. The international mobility of scientists and researchers may thus have positive effects on knowledge creation.\textsuperscript{14}

Brain exchange and brain circulation

In the context of increased globalization and knowledge based economies, some authors argue against the concept of return as it indicates the closure of a migration cycle (King 2000). Traditionally, return migration\textsuperscript{15} has been viewed as a popular strategy to reverse the brain drain. However, the current situation would tend to imply many types of return, circulation and recirculation of brains (Wickramasekara 2003). In order to reflect the complexity of the phenomenon, a new concept has been introduced, namely the ‘brain circulation’, which refers to the cycle of moving abroad to study, then taking a job there, and later returning home to take advantage of a good opportunity (Gaillard and Gaillard 1998, Johnson and Regets 1998). Saxenian (2000, 2002a, b) has for example emphasized the importance of transnational entrepreneurs in the development of parallel ‘Silicon valleys’ in cities such as Bangalore, Bombay, Beijing, Shanghai and Taipei by circulating immigrants who brought back their experience and skills. This concept is different from brain exchange as the same skilled persons are commuting back and forth between source and destination countries. Scientific/academic (or knowledge) networks play also an important role in this context of brain circulation, as well as knowledge networks and scientific diasporas, notably for developing countries (transfer of knowledge and experience through periodic visits to home country, knowledge networks of nationals).

To conclude, a brain drain situation may be assimilated to permanent and irreversible emigration and may have harmful consequences on sending countries. Brain circulation, which is one component of the flow of goods and information in a globalizing world\textsuperscript{16}, may characterize a situation in which the human capital that has emigrated may return home after a few years bringing along accumulated knowledge, skills, contacts, access to international best practices and financial capital. Actually, traditional brain drain co-exists with brain circulation. The form of mobility implied by brain circulation, if often perceived as positive as it generates knowledge transfers, is supplementary rather than opposite to brain drain. Indeed, countries might win or lose from scientific migration depending on the length and nature of the mobility (Casey et al. 2001). A loss might be experienced by a sending country if mobility is long term or permanent and is not offset by inward scientific mobility. A gain might be observed if mobility is more circular, implying scientists’ return and inward migration of scientists from other countries, or if there are knowledge exchanges with the home country.

2. The flows of Ph.D.s and post-docs: scarce evidence of a European brain drain…

What is the net balance of exchanges of Ph.D.s and post-docs between Europe and the United States? That is the question which we would like to answer in this section with a standard analysis of the flows of Ph.D.s.

Firstly, we present briefly the recent evolution of doctoral education in Europe and in the United States. Secondly, we analyse the data on the number and origin of foreign Ph.D. students in these countries. Thirdly, we carry out the same type of analysis for the post-doctoral workforce.

\textsuperscript{14} A recent theoretical model (Dos Santos and Postel-Vinay 2003) shows that emigration increases the knowledge stock of the source country and is always beneficial. However, if individual heterogeneity of the knowledge stock is taken into account, Lien (2005) suggests that the Dos Santos and Postel-Vinay modified model provides a classical brain drain. Emigration is good to the source country only when a sufficient number of emigrants return.

\textsuperscript{15} Glaser (1978) showed that the attachment to home country and the desire to come back home seems generally to be important.

\textsuperscript{16} This might characterize all advanced economies (Lowell and Findlay 2001).
2.1. Doctoral education in Europe and the United States: recent evolutions

In this section we use NSF harmonized data on the number of Ph.D. graduates in four countries: France, Germany, United Kingdom and United States (See Figures 1 – 6 in Annex 1).

When necessary, we supplement these data by specific data from MENSFR for France (See Figures 9 and 10 in Annex 1), HESA for the United Kingdom (See Figures 11 and 12) and NSF for the United States (See Figures 7 and 8 in Annex 1). In those cases, the grouping of disciplines is organised so that data are (more or less) comparable. In a first stance, we use two main broad fields of disciplines:

- Science and engineering (S&E) which contains all the natural science disciplines: physical sciences (physics, chemistry, geosciences), engineering, life sciences (biology and health-related fields), mathematics and computer sciences.
- Social sciences and humanities (e.g., arts, humanities, sociology and economics).

Then, we attempt to decompose this grouping by isolating some of the above mentioned fields.

At the Ph.D. level, there was a steady increase in the enrolments in Ph.D. studies between the mid-1980s and the mid-1990s in many countries. The number of Ph.D. graduates followed the enrolments in Ph.D. studies after a time lag of 3-4 years.\(^{17}\) This increasing trend was followed by a levelling-off and, in some cases, like France and the United States, in some specific fields, a decrease in the number of Ph.D. graduates.

In the USA, two main periods of sharp increase in the total number of annual doctorates awarded by universities can be discerned. The first one took place between 1961 and 1971. During this period, the number of Ph.D.s granted increased from 10,000 up to 30,000.\(^{18}\) The second period of steady increase began in 1986 and ended in the mid-1990s. This second wave of growth in the 1980s is explained by the increases in academic R&D budgets in some scientific fields. The growth in the annual number of doctorates granted became smaller in 1997 and 1998, and the number of doctorates awarded declined in 1999.\(^{19}\)

In France, a sharp growth can also be observed between the mid-1980s and the mid-1990s. The growth is largest between 1986 and 1994. Then, the annual number of Ph.D.s awarded increased slowly and declined in 1998 and 1999 respectively.

In the UK, the growth in the number of Ph.D. graduates was significant from 1995 to 2004. We can distinguish two main periods. The first one, lasted from 1995 to 2001, during which we observe an important growth in nearly all disciplines. The second one, from 2001 to 2004, is characterised by slow growth or a decrease in some specific disciplines.

In Germany, the growth has been more regular on the last 30 years with a period of stabilisation at the beginning of the 1990s. More recently, there has also been a levelling off and a decrease in some disciplines.

By broad fields, the USA and France offered similar patterns in the number of Ph.D.s awarded annually. Broadly speaking, in the natural sciences, a sharp increase has been observed in the annual number of doctorates awarded between the mid-1980s and the mid-1990s. By contrast, in the second half of the 1990s, there is a clear decrease. In the arts, social sciences and humanities, the increase began later (at the beginning of the 1990s) and continues until now, even if at a slow rate of growth.

In the USA, the computer sciences, mathematics and physics-astronomy are the three fields with the most significant growth between the mid-1980s and the mid-1990s. The growth in the engineering

\(^{17}\) Depending on the mean duration and on the drop out rates in the different disciplines.

\(^{18}\) This first upsurge reflected the impact of the Cold War and the space race.

\(^{19}\) Even if there was an overall increase of 0.8% in doctorates awarded between 1999 and 2000.
field was also significant. The behaviour in the life sciences is more particular: the growth was less significant at the end of the 1980s\textsuperscript{20}, but it continued until the end of the 1990s.

In France, similar patterns are observed. The increase in the natural sciences is significant between the mid-1980s and the mid-1990s and there is a decline in the second half of the 1990s. And this decline is less strong in the life sciences than in the other scientific fields.

In the UK, from 1995 to 2001 the annual growth rates are higher than 10\% in the social sciences and humanities, medicine and related disciplines and biology. From 2001 to 2004, the growth continues, even if less strong, in medicine and biology. The growth is also quite significant in mathematics and computer sciences (+5\% per year).

In Germany, the number of Ph.D. graduates in natural sciences increased until 1998, and then decreased. In mathematics and computer sciences, the number of Ph.D. graduates increased from 1995 such as in engineering, the number stabilised from 1992 onwards.

Even if the number of Ph.D. graduates continues to grow in many countries, worries are expressed concerning future growth. The competition to recruit international students between regions might thus be increasing.

2.2. Foreign Ph.D. students in Europe and in the United States

First, we will give some elements on the distribution of foreign students at the tertiary level throughout the world. Then, we will study specifically doctoral education.

The distribution of foreign students worldwide (all tertiary levels)

In the world, in 2002, there were 1.90 million students enrolled outside their country of origin, of which 94\% studied in the OECD area (OECD 2004b, European Commission 2004).

It is worth noting that the data used here are based on the nationality of individuals. A foreign student is indeed someone who is not a citizen of their country of study. This concept does not clearly measure the international mobility of individuals, as foreign students are not necessarily mobile.\textsuperscript{21}

From 1998 to 2002, the absolute number of foreign students reported in the OECD area increased by 34.2\%. Five countries accounted for 73\% of all students studying abroad. The United States hosted 583,000 foreign students – the largest share (30\%) for a single country – whereas the EU-15 hosted 795,000 foreign students (Germany and the UK receive 12\% each of the world total of foreign students while receives France 9\%). The EU intra-mobility (migration between EU countries) was of about 250,000 students in 1999 (European Commission 2003d, p. 223-224).

In the USA, most of the foreign students came from Asian countries, with China, India and South Korea ranking the highest\textsuperscript{22}. Germany (number 11 on the list) and the UK (number 14), the first two European countries on the list, sent fewer than 10,000 students to the United States. In the EU, most of the foreign students came from EU member states, with Greek students being the most internationally mobile (followed by the French, the Germans and the Italians). In the whole EU (in 1999), the largest

\textsuperscript{20} In the life sciences field, the biological sciences and health sciences accounted for all the growth. A decline in the number of doctorates is observed for the agricultural sciences over the whole period. And differences exist between biomedical and non-biomedical sciences. All the growth has been concentrated in the biomedical fields. Cf. National Research Council (1998).

\textsuperscript{21} ‘It is impossible to distinguish between foreign students who are residents in the country but who have immigrated (or whose parents have immigrated), and students who came to the country expressly to pursue their education.’ (OECD 2004b, p. 296).

\textsuperscript{22} In 1999, the number of students from Asia in the U.S. system was estimated to be 300,000.
groups of non-EU students came from Asia and Oceania (180,000), from Africa (120,000) and from other European countries (110,000).

However, within the individual EU-15 countries, the numbers and the origin of foreign students vary greatly. This is partly explained by the former colonial relationships of the different member states. In that respect, Asia, and mostly China, is the source of the largest group of foreign students in the UK and Germany, while in France, the largest group of foreign students come from African countries.

To take into account the size of the different national education systems, it is possible to calculate the intake of tertiary students in a particular country relative to its tertiary enrolments. In that respect, Australia and Switzerland receive the largest proportion of foreign students with respectively 17.7% and 17.2% of tertiary students enrolled in the country being foreign. The proportion of foreign students is also of importance in Austria, Belgium, France, Germany and the United Kingdom (between 10 and 13%). By comparison, in the United States, foreign students represented only 3.4% of tertiary enrolments.

The relative measurement of departures from each country (number of students of a particular citizenship studying abroad, relative to national tertiary enrolments) shows that a low level of relative ‘mobility’ is observed in the United States (0.2%) and in the United Kingdom (1.2%), whereas France (2.5%) and Germany (2.6%) have higher ratios of students studying abroad to total enrolments. However this indicator has two drawbacks: i) it only covers students leaving their country to study in OECD and partner countries reporting data; ii) it is calculated on a full academic year.

By combining the two previous indicators, it is possible to establish the relative net balance for each country in calculating the net intake of foreign students in a specific country relative to the size of its tertiary education system. The United States has a relative intake of 1.6% whereas the corresponding figures are 5.1% for the United Kingdom, 3% for Germany and -0.1% for France. It is worth noting that the UK has one of the highest relative rates of intake in the OECD area as it is only outnumbered by Australia (8.1%) and Switzerland (7.5%).

If we consider now the EU level, ‘the EU is a net recipient of students from Asia, Oceania and other European countries, and most probably also from Africa and Latin America.’ (European Commission 2003d, p. 223). On the contrary, the U.S. and Canada have a net balance in their favour of more than 20,000 students (See Figure 13 in Annex 1). ‘[…] (S)tudents going to the U.S. form the most significant outward stream from the EU. The student influx into the EU from the U.S. and Canada remains low compared to the influx from other world regions. The EU is the net recipient of 380,000 students from all other world regions, while the U.S. and Canada are net recipients of 400,000 students. All other regions are net senders.’ (European Commission 2003d, p. 224).

Foreign students at the doctoral level

Data from OECD publications such as *Education at A Glance* and *International Migration* are of little utility here as generally they do not isolate specifically the Ph.D. level. Here we will use once more national data from NSF, MENSR and HESA.

Foreign students earn a larger proportion of degrees from U.S. universities at the doctoral level than at any other degree level. Each year from 1986 to 1996, increasing numbers of foreign students earned S&E doctoral degrees from U.S. universities. The number of such degrees earned by foreign

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23 Data based on the number of students enrolled in tertiary education in 1999 by region of origin, including permanent and non-permanent residents.

24 We can simply observe an asymmetry in global numbers between Europe and the United States: ‘there are approximately 450,000 people persons born in the United States living in Europe but 4.6 million persons born in Europe and living in the United States (of which 70,600 persons were born in Austria).’ (OECD 2005).
students increased by 7.8% each year while those earned by U.S. citizens increased only by 2% annually, on average. However, this increasing trend in the number of S&E doctoral degrees earned by foreign students halted in 1997. In 1996, nearly 40% of the total number of S&E degrees were earned by foreign students. This increasing trend seems to be applicable over a longer period: ‘In 1960-66, 12.8% of all doctoral degrees awarded by U.S. universities were to those of foreign origin […], compared to less than 6.0% in the period 1920-1939.’ (Bayer 1968, p. 468).

From 1985 to 2000, students from 11 major foreign countries together accounted for nearly 70% of all foreign recipients of U.S. S&E doctorates. Asia is the major source, even if U.S. S&E doctorates earned by Asian students declined from the late 1990s after having increased from the mid-1980s to that point. In the 1985-2000 period, Asian recipients earned nearly 69,000 U.S. S&E doctorates while recipients from Europe accounted only for 16,000 (with respectively 11,000 for Western Europe, 1,000 for Scandinavian countries and 4,000 for Eastern Europe). The major Asian countries sending doctoral students to the United States have been China (27,000), Taiwan (15,000), India (13,000), and South Korea (13,000). The major European countries of origin have been Germany, Greece, the United Kingdom, Italy, and France.

Some European countries also have a large percentage of foreign students in their S&E doctoral programs (See Table 1 and Table 2 in Annex 2). In 1999, foreign students earned nearly a fourth of the doctoral degrees awarded in France, but this proportion has been declining (up from one third) since the beginning of the 1990s. In the UK, 36% (in 2003-04) of doctoral degrees are earned by foreign citizens. This proportion has been relatively stable for ten years now. Conversely, in Germany there is a modest percentage of foreign students among S&E doctoral degree recipients (7% for all disciplines, 9.3% in S&E fields, for 2001).

In France and the UK, the percentages of foreign Ph.D. students vary greatly by discipline, with engineering and maths and computer sciences having the highest proportion of foreigners.

The origins of foreign doctoral students are also clearly different in France and in the UK. EU students represented about one fifth of foreign doctoral holders in 1999 in France while African students accounted for nearly 40% (with 25% for three countries: Algeria, Marocco and Tunisia). Middle Eastern, Asian and South American students accounted for 10% each. In the UK, the proportion of EU students among foreign Ph.D. holders was one third (Germany, Greece and Italy ranking highest). Asia is also an important contributor.

To sum up, despite the lack of complete data, it seems clear that there is an asymmetry in the flows of Ph.D. students between Europe and the United States, to the advantage of this latter country. Indeed, the flow of European Ph.D. students to the United States is clearly higher than the corresponding flow of U.S. Ph.D. students to Europe. Some countries and some disciplines tend to be particularly affected. However, the proportion of foreign Ph.D.s is not negligible in many European countries, but the origin of foreign Ph.D. students is diverse and different in each country and each discipline.

2.3. The post-doctoral workforce in Europe and in the United States

The data on post-doctorates is weaker than those for the Ph.D. level, except in the United States. Indeed, there is not an official definition of post-doctorate. In the United States, the data on post-docs


27 For more details see tables 2-9 and 2-10 (p. 2-31), from the National Science Board (2004).

28 Unfortunately, it is impossible to calculate the net intake in the way we did it for all tertiary levels.

29 Even if some countries are attempting to implement a definition (Auriol 2004).
come from the NSF Survey of Graduate Students and Post-doctorates in Science and Engineering (GSS). The main advantage of this source is that it is NSF’s only source of data on foreign-degreed post-docs. To that purpose, the data provided in the following paragraphs are from this survey. The main weaknesses of the GSS are that it only contains data at the department level (no individual data) and it does not include post-doctorates in non-profit institutions, government agencies, industry or post-docs who are not in formal academic departments. These data combined with other sources (and particularly the Survey of Doctorate Recipients, which does not include data on foreign-earned degrees) lead us to estimate that the total number of post-docs in the United States may be higher than 50,000 in 2001. In Europe, there are some ad-hoc surveys, conducted by post-doc associations and funding bodies, which provide some information on post-doctorates. That will be our only source of data for EU countries.

In the United States, temporary residents account for an increasing portion of post-doctorate positions, rising from 33% in 1979 to more than 50% from the end of the 1990s (See Figure 14 in Annex 1).

In absolute terms, the number of post-doctorates in life sciences in the United States who are foreign temporary residents, increased from 3,200 at the beginning of the 1980s to 17,000 in 2001. At the same time, the corresponding numbers of foreign temporary resident post-doctorates in physical sciences and engineering increased, respectively, from 2,200 and 700 to 4,200 and 2,200.

In 2000, the number of French post-doctorates in the United States was estimated between 2,000 and 3,000. In France, post-doctorate research was not a common experience until the late 1970s. However, the increase in the number of Ph.D. graduates, the lack of funding available for post-docs in France and the internationalisation of science have increased the number of French Ph.D.s seeking post-doc positions abroad. In a survey carried out by Céreq in 1999, three years after the completion of the doctorate, one-fifth of French Ph.D. graduates still held a post-doctorate appointment (40% in life sciences).

In a survey we carried out at Irédu in 2001 on 500 French Ph.D. graduates in natural sciences, 30% of individuals who held a post-doctorate appointment were located in the United States (See Table 3 in Annex 2), 9% in Japan, 5% in the United Kingdom, 4% in Canada, 4% in Germany, 2% in Belgium and 2% in The Netherlands. Nearly half of French post-doctorates who were abroad, were located in the United States.

A similar conclusion arises for Germany where 66.3% of DFG post-doctorates were located in the United States, 6.5% in the United Kingdom, 4.8% in Canada, 4.6% in France, 2.8% in Switzerland and 1.5% in Italy.

A qualitative study by Casey et al (2001) on academic careers and recruitment in ICT and biotechnology points out that ‘The “Been to America” is an undeniably important factor in European research. […] The U.S. system is hugely attractive to EU researchers at the Ph.D. and post-doc level [but within Europe] the main destination of scientific researchers seems to be the top universities of the UK.’ (p. 39-41).

In the case of the UK, a study on the physics field concluded that ‘the data […] show over one in five of the Doctoral graduates entering overseas employment. As these data include a large number of overseas students returning overseas, this is as expected. However, large numbers of EPSRC-funded doctoral graduates also move overseas to post-doctoral or other employment’ (Jagger 2001, p. 32).

31 About 75% of postdoctorates are employed in academic institutions. Thus, the total number of postdoctorates is about 53,000 (40,000 / 0.75).
32 Seznec and Martin-Rovet (2001).
33 For more details see Moguérou (2004b) and for other aspects of the French doctoral labour market, see Béret et al. (2003).
34 From a survey carried out on 1,422 DFG post-doctorates. Cf. Enders and Mugabushaka (2004). See also below.
A survey carried out by Dedieu and Musselin on foreign post-doctorates in French public research institutions concludes that in chemistry and life sciences, foreign post-doctorates make up between 30% and 50% of the staff of public labs. However, according to the authors, France experiences difficulties in attracting foreign post-doctorates from countries renowned for the quality of their research structures. Only few dynamic French public labs succeed in recruiting ‘à l’américaine’.

In contrast, American citizens prefer to stay in the United States on a post-doc appointment rather than to go abroad, even if measures are taken to increase their international mobility. One example is the NSF’s International Research Fellowship Program (IRFP) which provides support for early-career scientists and engineers to conduct research abroad. However, only about 40 young post-doctoral researchers received grants from the IRFP in 2001.

To conclude, international mobility is particularly high among post-doctorates and is almost exclusively concentrated in the life sciences. The United States seems to attract post-doctorates from all over the world. North America, and especially the United States, is a major destination for European post-docs, even if a number of them are only staying in the EU (and particularly in the United Kingdom). European countries succeed in recruiting international post-docs, but certainly few U.S. citizens. Each individual European country has less global recruitment than the United States. However, one has to remember that these conclusions are based on imperfect data as the lack of data on this issue is a greater issue than it is for the Ph.D.-level data.

3. What needs to be discussed in greater depth

From the previous section it appears that the flows of Ph.D. students from Europe to the United States, and certainly of post-doctorates, is higher than the corresponding flows from the United States to Europe. However, it does not allow us to draw any definitive conclusion on the European brain drain question as a number of issues remain unsolved.

First, the return migration of European Ph.D. students and post-doctorates has to be studied. Second, the net balances in the brain-gain and brain-loss have to be considered and placed in relation to the stock of Ph.D.s in different countries. Third, it would be useful to have information on the ‘quality’ of Ph.D. students and post-doctorates who ‘circulate’. We conclude this section by promoting the creation of a statistical information system on Ph.D.s in Europe, an instrument essential for having a wider perspective on the European Research Area.

3.1. Return migration

The impact of the out-migration of Ph.D. students and post-doctorates on European countries depends clearly on their stay rates in receiving countries. 35 How many of them will return to their home countries after their period in the United States?

Historically, about half of foreign students who earned S&E degrees at universities in the United States reported that they planned to stay in the United States. 36 However, these percentages seem to have increased in the 1990s. In the 1990–93 period, for example, of the foreign S&E doctoral degree recipients who reported their plans, 63% planned to remain in the United States after receiving their

35 Similarly, degree to which the USA relies on the inflow of foreign Ph.D.s depends also on return migration. The situation is actually more complex than the simple observation of stay rates as the dynamics of the processes are important (and notably the duration of stay that may evolve). However, the lack of data clearly limits the type of analysis we are able to undertake.

36 National Science Foundation (1998).
degree, and 41% had firm offers. By the 1998–2001 period, 76% of foreign doctoral degree recipients in S&E fields with known plans intended to stay in the United States, and 54% accepted firm offers to do so.\(^\text{37}\)

Stay rates vary greatly by place of origin. In 2001, 70 and 77% of S&E doctoral degree recipients from China and India respectively, reported accepting firm offers for employment or post-doctorates in the United States. This was the case of only about half of new U.S. doctorate holders from South Korea and Taiwan. About 60% of U.S. S&E doctoral degree recipients from the United Kingdom had firm plans to stay in the United States. This high percentage has been relatively constant over the long term. On the contrary, historically, France and Italy had smaller percentages of their U.S. doctoral holders planning to stay in the USA. However, there has been an increasing trend recently, for these two countries. Between the period 1994-97 and the period 1998-2001, the percentage of doctoral degree students from these countries who had firm plans to stay in the United States grew from about 32% to about 49%.\(^\text{38}\) A similar upward trend is observed for Germany, even if it is far less significant. The factors affecting the decision to stay in the United States are numerous and inter-related (e.g., strength of pre-existing ties to the home country, multiplicity of sources of funding, easier access to leading technologies and job opportunities). However, career perspectives and prospects at home, and notably the recent difficulties experienced by Ph.D. graduates in France and Italy, may be linked to this upward trend.

In France, according to a survey carried out by Céreq in 1999, only a small proportion of the French Ph.D.s who qualified in 1996, were living abroad in 1999 (7%). ‘Among those living abroad in 1999, only 21% did not wish to return to France’ (Martinelli 2002, p. 126). It is mostly Ph.D.s in disciplines where job opportunities do not abound who move abroad: 15% of graduates in natural and life sciences were living abroad after three years on the labour market.

In Germany, a recent survey\(^\text{39}\) carried out in December 2002, commissioned by the German Research Foundation (DFG), based on a wide-ranging report studying career paths and opinions of previous recipients of DFG post-doctoral fellowships,\(^\text{40}\) indicates that 85% of scientists who leave Germany for work or research abroad eventually return to jobs in Germany. The final sample is of 1,422 recipients from 1986–1987, 1991–1992, and 1996–1997, in four broad science areas: social sciences, biology and medicine, natural sciences, and engineering. Seventy-two percent of individuals worked abroad during at least part of their fellowship. The United States, as we indicated above, was the first destination for 66.3% of those who worked abroad. But only 15% of recipients were still living abroad at the time of the study, and, among them, 40% were in the United States and 40% in Western Europe.\(^\text{41}\) The percentages of individuals who did not return are, respectively, 19% and 17% for the natural sciences and biology/medicine.

### 3.2. The loss of brains relative to the stocks

The net balances in brain-gain and brain-loss should be placed in relation to the stock of Ph.D. students and post-doctorates in those countries. Unfortunately, this estimate is difficult to do with the available data.

In studying the return migration of EU-born U.S. doctorate recipients, the EC concluded: ‘The “brain drain” of people born in the EU is increasing. About 75% of EU-born U.S. doctorate recipients who graduated between 1991 and 2000 had no specific plans to return to the EU, and more and more

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38 For more details, see National Science Board (2004), chapter 2. See also Finn (2003) and Gupta, Nerad and Cerny (2003).
40 These fellowships are a major source of postdoctoral funding for top young German scientists.
41 However, nothing is said about the relative ‘quality’ of those researchers.
are choosing to stay in the United States." They were called the ‘lost sons of Europe’. However, this conclusion has to be qualified. Indeed, this figure translated to almost 11,000 of the 15,600 or so EU-born U.S. doctorate recipients telling of their plans to stay in the United States, and has to be compared to some 500,000 Ph.D.s awarded in Europe during the same period (in 2001, the number of Ph.D. recipients in Europe was estimated to be higher than 70,000 (cf. Table 1 in Annex 2). Moreover, this figure does not say anything about EU-born doctorate recipients from European universities, present in the United States.

At the post-doctoral level, the evidence is scarcer as there is no data on the number of post-doctorates in Europe and as the return migration of EU-born post-docs who were in U.S. universities, is difficult to assess.

3.3. Quality issues

What about the ‘quality’ of European Ph.D. students and post-doctorates who emigrate and foreign Ph.D.s and post-docs who immigrate to Europe? Unfortunately, we are not able to say much about it. From a survey on French post-doctorates (Moguérou 2004b), we can simply conclude that Ph.D.s who move to the United States for a post-doc period had a higher productivity during their Ph.D. thesis (as measured by the number of publications and attendance at conferences) than those who stay in France. Some other studies attempted to answer this type of question for emigrant scientists and engineers. Their conclusion, as summarized by Commander et al. (2003), indicate that ‘foreign-born scientists have tended to earn significantly more on average than native ones. This might suggest that they represent the higher end of the ability scale (if we assume that abilities have the same distribution in all countries) and/or that they have the incentive to put more effort into their work.’ Recently, Saint-Paul (2004) found that the skill level of European born immigrants in the U.S. is substantially higher than in Europe.

The quality question is also of importance in the return migration processes. Indeed, the observation of stay rates would have to be completed by an analysis of the ‘quality’ of researchers who come back home. Who returns and with what (additional) competences after a period abroad? In that perspective, high stay rates in sending countries might be offset by the return home of the most talented researchers who bring back with them the benefits of their period abroad (additional skills, know-how, networks and contacts, etc.). To the contrary, a few star scientists who never return may be harmful for the national innovation system even if low stay rates in sending countries are observed.

In some cases the European brain drain might have been overestimated, notably because return migration was not taken into account and because numbers were given without providing any indication of the scale of flows. Moreover, uncertainty remains about the ‘quality’ of Ph.D. students and post-doctorates who emigrate to the United States and those who emigrate within Europe. In a number of fields the United States, is without a doubt, dominant and certainly attracts the most

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43 In the same EC Press Release (IP/03/1594, 25/11/2003) we find other alarming expressions: ‘Brain drain: a lost human capital for Europe?’ and ‘Once they’ve left, they’re lost’.
44 He wrote (p. 15): ‘They are several times more likely to have a Ph.D. than the average U.S. labor market participants, and presumably than the average European resident.’
45 This conclusion is in line with the general analysis of the brain drain carried out by Docquier and Marfouk (2004). They conclude that ‘It is worth noticing that North-North brain drain did decrease over the last 10 years (except in a few countries where the changes were very small). The average migration rate of tertiary educated workers decreased by 3.15 points in Western Europe, by 2.19 points in Southern Europe and by 1.88 points in Northern Europe. […] The proportion of OECD educated migrants residing in the U.S. increased from 48% to 53% between 1990 and 2000. The European Union is the second destination, attracting 16.3% of the educated in 2000 and 15.2 in 1990 (the migration between European countries is counted).’
talented researchers, but without more precise data we can only express that sort of feeling. If this is the case, the loss may be huge for Europe and may have important negative consequences on its future growth and innovation.

3.4. A statistical information system on Ph.D.s yet to be developed in Europe (and yet essential for the ERA)

EU countries clearly lack a statistical information system on Ph.D. graduates to answer a number of questions which are essential for innovation and growth. The international mobility of researchers is, as we have shown, one domain particularly poor in relevant statistics. Furthermore, this lack of data is valid for nearly all the issues related to occupations and careers of Ph.D.s. An information system on careers of Ph.D. graduates should be developed at the EU level with the prospect of the development of the European Research Area. That is if highly qualified human resources in science and technology is considered to be an important issue.

Specific surveys would be needed to follow cohorts of Ph.D. students, and that type of data is far from being available today (Eurostat 2001, Recotillet 2003, Schaaper 2004, Auriol 2004). Indeed, registers and administrative data offer a rich set of indicators but their use is limited to a small number of countries, they are not always comparable and they do not contain individual data. Labour force surveys are widely available and comparable but their sample size is limited and the classifications used are not well adapted to studying the particular nature of scientific occupations and careers. Censuses are a rich source but they are not implemented on a regular basis.

An information system on the careers of Ph.D. graduates, similar to the U.S. SESTAT system (which combines the SDR and SED surveys for the doctorate level), would be highly useful. This instrument should be based on comparable surveys able to follow cohorts of Ph.D. students on a long period of time, from the beginning of the Ph.D. thesis to 10 or 20 years after their entry into the labour market. The international dimension of scientific careers (from Ph.D. and post-doc training) should be of particular attention.

Conclusion

In this paper we have discussed the so-called European brain drain at the Ph.D. and post-doctoral level. It seems clear that there is an asymmetry in the flows of Ph.D. students between Europe and the United States, to the advantage of this latter country. Indeed, the flow of European Ph.D. students to the United States is clearly higher than the corresponding flow of U.S. Ph.D. students to Europe. For some countries and some disciplines there may be particularly negative effect. However, the proportion of foreign Ph.D.s is not negligible in many European countries, but the origin of foreign Ph.D. students is diverse and different in each country and each discipline.

International mobility is particularly high among post-doctorates and is almost exclusively concentrated in life sciences. The United States seems to attract post-doctorates from all over the world. North America, and especially the United States, is a major destination for European post-docs, even if a number of them are staying in the EU (and particularly in the United Kingdom). European countries succeed in recruiting international post-docs, but certainly few U.S. citizens. Furthermore each European individual country has less global recruitment than the United States.

However, these conclusions are based on incomplete and imperfect data, particularly at the post-doctoral level, and it does not allow us to draw any definitive conclusion on the European brain drain question, as a number of issues remain unsolved. First, few things are known on the return migration of European Ph.D. students and post-doctorates. Second, the net balances in the brain-gain and brain-loss have to be placed in relation to the stock of Ph.D.s in different countries. Third, uncertainty remains about the ‘quality’ of Ph.D. students and post-doctorates who emigrate to the United States.
and those who emigrate within Europe. In some cases the European brain drain might have been
overestimated as these issues were not considered seriously and as the presuppositions about the
European brain drain were simplistic. In a number of fields the United States is without a doubt
dominant and certainly attracts the most talented researchers, but without more precise data we can
only express that sort of feeling. If this is the case, it might have important negative consequences on
the future growth and innovation of European countries.

EU countries clearly lack a statistical information system on Ph.D. graduates to answer a number of
questions yet essential for innovation and growth. The international mobility of researchers is
particularly lacking in relevant statistics, but this mirrors the limited availability of data in nearly all
other issues related to occupations and careers of Ph.D.s. An information system on the careers of
Ph.D. graduates should be developed at the EU level. It is an essential tool for the implementation and
benchmarking of the progress towards the European Research Area.

In a recent article in *Foreign Affairs*, Bhagwati (2003) identified three key migration issues: the
brain drain, unskilled migrants and involuntary migration. The brain drain from developing countries
is clearly a critical problem. The risk of a brain drain damaging Europe and more generally rich
countries is, in our view, lower, but it might exist. Our analysis of the two way flows of Ph.D.s and
post-doctorates between Europe and the United States showed that the EU countries certainly lag
behind in this competition. However, the EU receives a big amount of brain gain from other parts of
the world (Africa, Asia and East European countries).

International mobility is valuable as it may increase the knowledge at home if there are return
migrations or knowledge exchanges with the home country. Excellence in science generally requires a
high degree of international interaction. The current situation tends to imply many types of return,
circulation and recirculation of brains. Actually, traditional brain drain and brain gain co-exist with
brain circulation. A brain gain is to a large extent a matter of brain circulation or increased
international mobility. It must be recognised that a certain brain loss may be a price worth paying for
the benefits arising from the international mobility of a country’s scientists.

Europe has to be careful in implementing migration policies – and this implementation requires,
first, a correct assessment of the European brain drain which considers seriously the three unsolved
issues presented in this paper, if it wants to experience a balanced migration, a brain circulation rather
than brain gain that would be obtained at the expense of developing countries. The challenge is to
facilitate the circulation of brains while generating benefits for both sending and receiving countries.
A proper goal would be to create a win-win situation, or a balance between brain gain here and brain
drain there.
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Annex 1: Figures

Figure 1. Total number of Ph.D. graduates


Figure 2. Number of Ph.D. graduates in S&E disciplines (natural sciences, engineering and social sciences)

Figure 3. Number of Ph.D. graduates in natural sciences and engineering


Figure 4. Number of Ph.D. graduates in natural sciences (physical, biological, earth, atmospheric, and ocean sciences)

Figure 5. Number of Ph.D. graduates in mathematical and computer sciences


Figure 6. Number of Ph.D. graduates in engineering

Figure 7. USA: number of Ph.D. graduates (1966-2000)

Source: Survey of Earned Doctorates (2001), Doctorate Records File, NORC.

Figure 8. USA: number of Ph.D. graduates in S&E disciplines (1966-2000)

Figure 9. France: number of Ph.D. graduates (1992-99)

Source: Rapports sur les Etudes Doctorales.

Figure 10. France: number of Ph.D. graduates by detailed disciplines (1992-99)

Source: Rapports sur les Etudes Doctorales.
Figure 11. UK: number of Ph.D. graduates (1995-2004)

Source: HESA.

Figure 12. UK: number of Ph.D. graduates by detailed disciplines (1985-2004)

Source: HESA.
Figure 13. Number of foreign students enrolled in tertiary education by broad world regions (1999)

Source: Third European Report on S&T Indicators 2003 (European Commission 2003d, p. 224). Notes: the value inside the box represents the migration figure within the particular world region. The EU figures do not include EL and P. The host regions only include the OECD member states. ‘Asia+Oceania’ is Japan, South Korea, Australia (1998) and New Zealand. ‘Other Europe’ is Hungary, Poland, the Czech Republic, Norway, Switzerland, Iceland, and Turkey. Africa has no OECD member states. Latin America has only Mexico. For the latter two world regions, the numbers of students they are hosting are not given. The regions of origin are complete.
The Brain Drain of Ph.D.s from Europe to the United States: What We Know and What We Would Like to Know

Figure 14. Number of post-doctorates in the United States (1977-2001)

Source: WebCASPAR database system.

Figure 15. Number of post-doctorates in the United States in 2001 by discipline and citizenship

### Annex 2: Tables

**Table 1. Annual production of Ph.D.s and proportion of foreigners in some OECD countries.**

<table>
<thead>
<tr>
<th>Country</th>
<th>Ph.D. graduates</th>
<th>Foreign Ph.D. students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per millions inhab.</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2733</td>
<td>380</td>
</tr>
<tr>
<td>Belgium</td>
<td>1147</td>
<td>112</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>11568</td>
<td>194</td>
</tr>
<tr>
<td>United States</td>
<td>44808</td>
<td>163</td>
</tr>
<tr>
<td>Australia</td>
<td>3687</td>
<td>191</td>
</tr>
<tr>
<td>Canada</td>
<td>3978</td>
<td>129</td>
</tr>
<tr>
<td>Norway</td>
<td>658</td>
<td>147</td>
</tr>
<tr>
<td><strong>OECD</strong></td>
<td><strong>147575</strong></td>
<td><strong>131</strong></td>
</tr>
<tr>
<td>Sweden</td>
<td>3049</td>
<td>344</td>
</tr>
<tr>
<td>Austria</td>
<td>1790</td>
<td>221</td>
</tr>
<tr>
<td>Spain</td>
<td>6007</td>
<td>150</td>
</tr>
<tr>
<td><strong>EU-15</strong></td>
<td><strong>70175</strong></td>
<td><strong>185</strong></td>
</tr>
<tr>
<td>Finland</td>
<td>1891</td>
<td>365</td>
</tr>
<tr>
<td>Portugal</td>
<td>1586</td>
<td>158</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>895</td>
<td>87</td>
</tr>
<tr>
<td>Italy</td>
<td>3557</td>
<td>62</td>
</tr>
<tr>
<td>South Korea</td>
<td>6143</td>
<td>131</td>
</tr>
</tbody>
</table>

Source: OECD, Education and MSTI Databases, 2002.

**Table 2. Doctoral S&E degrees earned by foreign students (2001, %).**

<table>
<thead>
<tr>
<th>Country</th>
<th>Natural sciences</th>
<th>Maths and computer sciences</th>
<th>Engineering</th>
<th>Social sciences</th>
<th>TOTAL S&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>France*</td>
<td>16.5</td>
<td>28.7</td>
<td>22.0</td>
<td>23.3</td>
<td>20.8</td>
</tr>
<tr>
<td>Germany</td>
<td>8.6</td>
<td>9.3</td>
<td>10.7</td>
<td>4.8</td>
<td>9.3</td>
</tr>
<tr>
<td>UK</td>
<td>25.6</td>
<td>43.5</td>
<td>51.2</td>
<td>48.0</td>
<td>36.9</td>
</tr>
<tr>
<td>USA</td>
<td>34.2</td>
<td>49.1</td>
<td>55.8</td>
<td>20.9</td>
<td>36.3</td>
</tr>
</tbody>
</table>


**Table 3. Location of post-doctorate for French Ph.D. graduates (%).**

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Physics</th>
<th>Chemistry</th>
<th>Biology</th>
<th>Maths-computer</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>41</td>
<td>31</td>
<td>36</td>
<td>8</td>
<td>38</td>
</tr>
<tr>
<td>USA</td>
<td>26</td>
<td>23</td>
<td>34</td>
<td>54</td>
<td>30</td>
</tr>
<tr>
<td>Other countries</td>
<td>33</td>
<td>46</td>
<td>29</td>
<td>38</td>
<td>32</td>
</tr>
</tbody>
</table>