

Unclassified

DSTI/EAS/STP/NESTI/RD(2004)25



Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

21-Sep-2004

English - Or. French

**DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY**

**DSTI/EAS/STP/NESTI/RD(2004)25
Unclassified**

Working Party of National Experts on Science and Technology Indicators

INTERNATIONAL MOBILITY OF DOCTORATE HOLDERS: TRENDS AND ISSUES AT STAKE

**WORKSHOP ON USER NEEDS FOR INDICATORS ON CAREERS OF DOCTORATE HOLDERS
OECD, Paris-La Défense, 27 September 2004**

Contact: Mohamed HARFI (Commissariat général du Plan, France); Tel: (+33 1) 45 56 53 26;
Fax: (+33 1) 45 56 54 84; E-mail: mharfi@plan.gouv.fr

JT00169570

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

English - Or. French

INTERNATIONAL MOBILITY OF DOCTORATE HOLDERS: TRENDS AND ISSUES AT STAKE¹

Mohamed HARFI,² Commissariat Général du Plan³

1. International mobility has become a key element in the process of accumulating human capital in research. It is a vector for sharing knowledge and personal enrichment. It is necessary for scientific excellence which relies on interaction between researchers at international level. It also ensures that public and private teaching establishments and research laboratories are competitive. The question, however, is how can this mobility be developed so that it is of benefit to the host country or the country of origin by improving their research potential. This is the key issue for all government decision makers who by means of a variety of policies (immigration policy, funding, etc) seek to attract highly qualified staff, especially the best foreign researchers, and to improve the rate of return of their citizens working abroad.

2. With regard to this question, three points should be underlined: 1) in the majority of industrialised countries, international mobility takes different forms and involves a considerable number of both public and private actors. 2) One of the chief worries of government decision makers concerns uncertainty about the magnitude of the “autonomous” component, outside international cooperation programmes between countries, of internationally mobile students, engineers and researchers. 3) An increasing number of students, especially at postgraduate level, do not return to their host [*sic*] country after training abroad. This phenomenon has aroused serious misgivings in the majority of countries of origin, heightened by the lack of reliable statistics to estimate the “loss” in terms of potential research and innovation. Despite this, an adequate reply to these questions must rely on the statistics that are available in this area. As we shall see, much remains to be done at this level.

3. In this paper, we shall address the question of the importance of international mobility of human resources in science and technology, especially doctorate holders, in a knowledge-based society (section I). We then present a matrix to characterise the questions and types of analysis to which the availability of internationally harmonised statistics and the use of appropriate indicators should contribute. The partial analyses which relate to certain aspects of the phenomenon (section II). The integrated analyses which relate international mobility to the more global issues of developments in systems of education, research and innovation, immigration, the labour market, and indeed the competitiveness of the host country and the country of origin (section III).

-
1. I would like to thank Professor Claude Mathieu, Academic-University of Paris XII and Scientific Adviser to the Commissariat général du Plan for his comments and suggestions.
 2. Head of mission, “Saraswati” project Chief”, Commissariat Général du Plan.
 3. All opinions expressed in this paper are the author’s and do not necessarily reflect views of the Commissariat general du Plan.

I. International mobility of doctorate holders: one of the challenges of the knowledge economy

4. Conscious of its role in the creation and spread of knowledge and the constitution of “development” capacity, the majority of countries have always encouraged international mobility. This is illustrated by the development of various forms of co-operation between countries in the same area or in economic and/or political integration areas.

5. The 1990s witnessed growing internationalisation and integration of the labour market for scientific and technical personnel. This trend can be explained partly by the advent of the knowledge economy which brought about a shortage of highly qualified personnel, in this case researchers and engineers, which acted as a constraint on some industrialised countries.⁴

6. In the future, several factors are likely to strengthen doctorate holders’ international mobility during the next decade:

- The ageing of the population of researchers and engineers in the public and private sector giving rise to considerable needs for “replacement”.
- The ambitious medium term goals of the industrialised countries in terms of investment in research and development (notably Europe in the framework of the Lisbon Strategy) giving rise to considerable needs for new recruitment in the years ahead.
- A significant decline in the breeding ground of human resources in science and engineering. For five years there has been a reduction in the number of students in science and technology, a phenomenon affecting all the OECD countries including the United States.⁵
- The growing internationalisation of higher education marked by greater international mobility among students. According to recent estimates, foreign student numbers are expected to increase five-fold over the next twenty years.⁶
- The growing internationalisation of firms’ research and development activities and thus their research teams.

7. Intensifying international competition, based in particular on capacity for innovation, has encouraged States, chiefly on the basis of strategic thinking, to acquire or strengthen their arrangements for establishing, attracting and retaining a “reservoir” of researchers and engineers. Particular attention is paid to the population of doctorate holders, regarded as an essential component in establishing and/or consolidating countries’ potential for research and innovation, and a source of future competitiveness for their economies. This interest in doctorate holders, moreover, concerns developing as much as developed countries as shown by European countries’ thinking concerning the scale of their nationals “one-way” mobility to the United States. It also concerns the degree of “dependency” of the domestic research and

4. For further information on this question, see for example “Labour shortages and the need for immigrants: A review of recent studies”, *Trends in international migration*, OECD, Paris

5. *The Science and Engineering Workforce: Realizing America’s Potential*, National Science Board, 14 August 2003.

6. In particular, the Australian study: “*Global Student Mobility 2025, Forecast of the Global Demand for International Higher Education*”, November 2002.

development system on the flows and “stocks” of foreign researchers, as shown in studies undertaken in the United States.⁷

8. Doctorate holders’ international mobility, and more broadly that of human resources in science and technology, is thus a growing focus of attention among government decision makers. However, their interest also concerns students, especially post-graduate students, as they are now the prime source of emigration of qualified personnel.

Table 1. Production of PhD graduates in OECD countries, 2000

2000	Total PhD graduates population		Foreign PhD population
	Number of graduates	Per million inhabitants	as a % of total students enrolled
Australia	3 687	191	21.4
Austria	1 790	221	14.2
Belgium	1 147	112	36.1
Canada	3 978	129	17.3
Czech Republic	895	87	6.4
Denmark	913	171	-
Finland	1 891	365	5.7
France	9 903	163	-
Germany	25 780	314	-
Hungary	717	72	-
Iceland ²	-	-	-
Ireland	501	132	-
Italy	3 557	62	1.1
Japan	12 192	96	-
Korea	6 143	131	1.3
Netherlands ¹	2 483	156	-
Norway	658	147	14.5
Poland ³	4 400	-	-
Portugal	1 586	158	6.1
Spain	6 007	150	12.4
Sweden	3 049	344	14.1
Switzerland	2 733	380	36.8
United Kingdom	11 568	194	34.0
United States	44 808	163	26.9
European Union	70 175	185	10.9
Total OECD	152 975	131	15.0

1. 1999 instead of 2000. 2. Iceland’s educational system has only recently offered PhD programmes and has traditionally sponsored the overseas training of PhDs. 3. Polish data from Central Statistical Office, 2001. Source: OECD, Education and MSTI databases, December 2002.

Source: Background paper for the ROME workshop on “Fostering the development of human resources for science and technology”, OECD, CNR, Rome, 5-6 June 2003

9. In addition, it should be noted that these policies fall within the framework of reform of the doctoral education systems in developed countries, characterised notably by three elements: developing and encouraging students to take doctorate courses, diversifying career opportunities for doctorate holders, and developing acceptance of interdisciplinary and multi-disciplinary approaches in doctoral education.

10. Few countries have a statistical system that can analyse trends in the international mobility of doctorate holders quantitatively and qualitatively.⁸ Some host countries, it is true, do have information on

7. See footnote 4.

8. On this point, see especially “International mobility of the highly skilled”, OECD, Paris, 2002.

foreign doctoral students and doctorate holders (cf. table 1) and qualified persons holding a doctor's degree (even if there are difficulties concerning data on flows and stocks⁹). However statistics on internationally mobile expatriates, doctoral students or doctorate holders, are patchy (numbers, flows, stocks, country of destination, organised/structured mobility versus autonomous, etc.).

II. Indicators of the international mobility of doctorate holders in the partial analyses

11. The principal analyses which particularly concern questions of international mobility of doctorate holders may be classified into six themes:

1) *The temporal dimension of international mobility of doctorate holders*

12. The temporal dimension is central to the analysis of the international mobility of doctorate holders. It concerns, on the one hand, the period of international mobility during the doctor's career and, on the other, its duration and periodicity.

- a) In what period does the international mobility of doctorate holders occur? In fact, analysis of the international mobility of doctorate holders reflects different concerns depending on the period when the doctor is mobile, *i.e.* while preparing their thesis, after obtaining the degree especially during the immediate post-doctorate period, and finally during his career after the post-doctorate period.
- The international mobility of students in order to study for a doctorate abroad (doctoral students) has grown considerably.¹⁰ This trend requires indicators which can identify doctoral students' motives (and/or country of origin) and the degree of attractiveness of the host country and the country of origin. It is the evaluation of the "autonomous" component of international student mobility, *i.e.* which occurs outside bilateral or multilateral cooperation agreements and the automatic monitoring system, which gives rise to the most problems, since measuring its scale in the country of origin is often difficult if not impossible without resorting to the statistical systems of international organisations (OECD, UNESCO). Moreover, apart from statistical indicators, trends analysis also means understanding the evolution of educational systems, paying particular attention to the specific features of doctoral education and their impact on this mobility.
 - The post-doctorate period is often one of the first phases in the doctor's career. It is a particular focus of attention for government decision makers. In certain disciplines, it is a necessary stage before entry into a long career in research. In others, rather, it is reflected in temporary and precarious work characteristic of the difficulties encountered by doctorate holders in the labour market. The international mobility of doctorate holders during this phase often gives rise to concerns for the country of origin. Indeed, this mobility may in reality be the first phase in definitive immigration. The analyses, however, are often based on partial statistics, whereas they

9. Cf. in particular the work in progress on the construction of an international database on expatriates in the OECD by level of qualification (Directorate for Employment, Labour and Social Affairs, Statistics and Indicators Division).

10. Recent studies suggest that during the next twenty years, the number of internationally mobile students in higher education will increase five-fold. See in particular the Australian study: "*Global Student Mobility 2025, Forecast of the Global Demand for International Higher Education*", November 2002; and "*Visions 2020, Forecasting international student mobility: a UK perspective*", British Council, Universities UK, IDP, 2004.

need to use statistics on immigration and the labour market situations of doctorate holders in the host countries and countries of origin.¹¹

- The indicators should allow an evaluation of the impact of the international mobility of doctorate holders, whether for a longer or shorter period, on their career after the post-doctorate phase. These indicators should also be linked to questions on the labour market situation in the country of origin compared with the host country. In addition, it is also important to consider the integration of foreign doctorate holders in the host country and on the “reintegration” of those who return to their country of origin.
- b) What is the duration and frequency of the international mobility of doctorate holders? Even the partial statistics, in fact, on the international mobility of doctorate holders show a multitude of situations which have neither the same causes nor the same consequences for the doctor himself and for the host country or country of origin. Although not exhaustive, two key points can be underlined:
- First of all, by measuring the duration and periodicity of international mobility, its temporary character or otherwise, the attractiveness of the host country and the impact of country of origin’s policies can be evaluated. Here too there is serious absence of statistics to estimate rates of return and “definitive” mobility, in particular by the acquisition of the nationality of the host country. Furthermore, what will be the impact on the application of mode 4 of the General Agreement on Trade in Services (GATS) on the international mobility of doctorate holders.¹²
 - Distinguishing between “*organised*” mobility, *i.e.* which takes place in the framework of *international scientific and technical cooperation*, and other forms of international mobility of doctorate holders is important for government decision makers. Indeed, in the absence of availability of statistical data, the concerns of countries of origin are fed by uncertainties concerning the scale of international mobility of doctorate holders outside international cooperation.

13. The temporal dimension, of course, has to be correlated with the spatial dimension by considering the doctorate holders’ places of education and where they exercise their professional activity.

2) *The “quality” of internationally mobile doctorate holders*

14. Government decision makers’ questions about the phenomena of Brain Drain and Brain Gain concern not only the quantitative but also the qualitative dimension of the international mobility of doctorate holders. The qualitative dimension here concerns not only the doctorate holders’ characteristics in terms of age, scientific discipline and sectors of activity, for example. It is also much more a case of their “scientific and technical quality”. Certain variables give an approximation of this, such as positions of responsibility held in public or private laboratories with a worldwide reputation for excellence, scientific

11. See COSEPUP Report, and “Postdocs: What we know and what we would like to know”, Proceedings of an NSF/CPST/Professional Societies Workshop, 4 December 2002.

12. See on this question Antoine Math (IRES) and Alexis Spire (CNRS, CERAPS-Lille) “Vers une immigration permanente de travailleurs temporaires” and “du mode 4 de l’AGCS aux différents régimes migratoires de travailleurs détachés”, Working Paper No. 04.06, IRES, June 2004.

reference works (and references), patents or reference to patents applied for, etc. Yet few studies address this question because it requires individual data over a long period.¹³

3) *The determining factors in doctorate holders' choices and countries' attractiveness*

15. Even if the choice of country or area of destination involves different phases in a doctor's career, there is no escaping that government decision makers are more interested in newly qualified doctorate holders. The fact is that students, who are becoming more and more internationally mobile in the sciences, constitute the breeding ground for researchers and engineers and the prime source of emigration of scientists. Various studies¹⁴ seek to evaluate changes related to doctorate holders' preferences and to identify the factors that explain their return to the country of origin. Analysis of this kind, which is important to government decision makers, requires the quantitative data to be complemented by sociological analyses. Such approaches, however, assume the availability of sample data, or even interview surveys.

16. Knowing doctorate holders' motives and the factors in their choice of location becomes important in defining the strategies of the host countries and countries of origin for this population.¹⁵ For the host countries and countries of origin this means evaluating the effectiveness of their strategies and their attractiveness (the characteristics of education systems and research, the labour market, highly qualified personnel, etc.). For developing or newly industrialised countries, these analyses would allow them to evaluate the impact of policies implemented in order to ensure a "good rate of return" of their personnel holding a doctorate, after their education or their post-doctoral mobility abroad. It should be noted, lastly, that some countries have developed policies aimed at mobilising better the scientific diaspora as a means of "internalising" the brain drain.¹⁶

4) *Analysis of sources of financing of international mobility of doctorate holders*

17. Analysing sources of financing of the international mobility of doctorate holders by stage in the career allows the impact on return to the country of origin or definitive mobility to the host country to be evaluated. A recent study analysing the reasons for foreign doctorate holders' decisions to stay or not stay in the United States¹⁷ shows that the principal source of financing is a crucial factor when making that decision. There is a significant difference between two groups of doctorate holders: over a quarter of those who returned to their country of origin financed their studies chiefly from domestic resources (grants or public or private employers) while 90% of those who stayed in the United States had financed their doctoral studies by working as teaching or research assistants. Such an analysis, however, must take account of countries' structural and economic situations (labour market, education system, research, etc.) and their strategy in the field.

13. See, for example, the summary by Thomas B. Hoffer "Employment sector, salaries, publishing and patenting activities of S&E Doctorate holders" InfoBrief 04-328, June 2004, based on NSF's 2001 and 1995 Survey of Doctorate Recipients.

14. See, for example, in the case of France and Germany, the work of Christine MUSSELIN and Jürgen ENDERS.

15. Including the strategies of higher education establishments and research organisations.

16. See on this question the collective work "*Scientific diasporas*", R. Barré, J-B Meyer, V. Hernandez, D.Vinck, Les éditions de l'IRD, Paris, 2004.

17. D. Gupa, M. Nerad and J Cerny, 2003 "International Ph.Ds: Exploring the decision to stay or return", International Higher Education, Spring 2003.

5) *International mobility and doctorate holders' careers in the private sector*

18. The share of firms in financing and carrying out research and development activities, and more generally their role in innovation has grown markedly in most industrialised countries. Thus the growth in quantities of resources devoted to the process of innovation is reflected in the recruitment of highly qualified labour, in particular doctorate holders. This situation offers new opportunities for doctorate holders, especially during the period where prospects of academic employment are reduced. The employability of young doctorate holders in the private sector is thus attracting more and more attention from government decision makers.¹⁸ Yet although academic careers are the subject of a wealth of literature at international level,¹⁹ determining factors in the careers of doctorate holders in the private sector and mobility between the two sectors are still little studied.²⁰

19. Furthermore, the internationalisation of industrial R&D, linked to the process of globalisation, is reinforcing the trend towards internationalisation of the labour market for highly qualified personnel, in particular doctorate holders. That also means the role of business in the development of the international mobility of doctorate holders,²¹ which could be enhanced by the development of mode 4 of the General Agreement on Trade in Services (GATS).²²

20. Thus understanding the international mobility of doctorate holders during their career in the private sector is important for government decision makers, since it can provide them with knowledge about it outside the sphere of academic employment or public employment in general.²³

6) *International mobility of doctorate holders by sector and discipline*

21. Studies of doctorate holders' careers highlight the significant differences between scientific disciplines and sectors of activity.²⁴ Moreover, in the 1990s particular attention was paid by the industrialised countries to the education and professional future of doctors in the life sciences,²⁵ information technology and mathematics. Having enough highly qualified staff, especially researchers in

18. For an overview of the question, see variable file 6.E "L'employabilité des docteurs dans le secteur privé", Opération Futuris, Recherche, Innovation, Société, January 2004.

19. See, for example, Stephan P., Levin S.G. (2001), "Career Stage, Benchmarking and Collective Research", *International Journal of Technology Management*, vol. 22, No. 7/8, and Diamond A. (2001), "Scientists' Salaries and the Implicit Contracts Theory of Labour Markets", *International Journal of Technology Management*, vol.22, pp. 159-173..

20. In France, studies on employment of doctorate holders in business are a little more numerous, see, for example, Martinelli *et al.*, 1998, "L'insertion récente des docteurs", CEREQ, Marseille, 1998.

21. A joint survey of R&R directors of multinational firms belonging to EIRMA by the Commissariat général du Plan and EIRMA in 2004 is an attempt to evaluate present and future trends.

22. See WTO, (1998) Council for Trade in Services: "Presence of Natural Persons (Mode 4) – Background Note by the Secretariat" S/C/W/75 of 8 December 1998; and OECD, (2001), "Service providers on the move: A closer look at labour mobility and the GATS" [TD/TC/WP(2001)26/REV1].

23. See, for example, the article by Stéphane Robin "Insertion des docteurs en sciences de la vie en France: secteur académique et secteur privé", 10th Céreq-Lasmas-IdL workshop, Caen, 21, 22 and 23 May 2003 "Les données longitudinales dans l'analyse du marché du travail".

24. See, for example, the case of human sciences in the report: "Doctoral futures: career destinations of arts and humanities research students, CUDAH, December 2002.

25. See, for example, Freeman R.B., Weinstein E. *et al.*, (2001), *Careers and Rewards in Bio Sciences: The Disconnect Between Scientific Progress and Career Progression*, scientific report.

these disciplines, was a response to the considerable needs linked to strong growth in the biotechnology and information and communication technology sectors. The international mobility of doctorate holders in these disciplines/sectors was often likened to the phenomena of Brain Drain or Brain Gain.

22. However, the objective of government decision makers is not only to look at strategic sectors. Above all, it involves adapting their policies to encourage more doctorate holders into academic careers or the private sector, taking account of the specific characteristics of sectors and disciplines. In addition, during the coming years, the considerable development of multi-disciplinary and inter-disciplinary approaches, necessary in a process of innovation in products and services, will reinforce decision makers' interest in these questions.

III) Integrated approaches to the analysis of international mobility of doctorate holders

23. In a knowledge-based economy, creating conditions favourable to production, the "absorption" and application of new knowledge presupposes an integrated approach to the analysis of international mobility of doctorate holders and highly-skilled personnel in general. Moreover, the development and diversity of doctorate holders' careers in the public and private sector expand the scope of the analysis. Whence the emergence of approaches analysing the effectiveness of education systems (in particular doctoral education), the structure of research systems and innovation, the functioning of the labour market and the impact of immigration policies. It should be noted that these approaches are increasingly taking on the character of forecasting. To illustrate this trend, three cases are presented: France, the European Union and the United States.

1) *The attractiveness of France for R&D activities: the Saraswati project*

24. The Saraswati project²⁶ is a forecast study of the attractiveness of France in the fields of research and development and innovation. The work is structured around three main pillars. The first pillar, now nearing completion, concerns student international mobility, including doctorate holders. The second pillar concerns international mobility of researchers and engineers and the third, the location of industrial research activities.

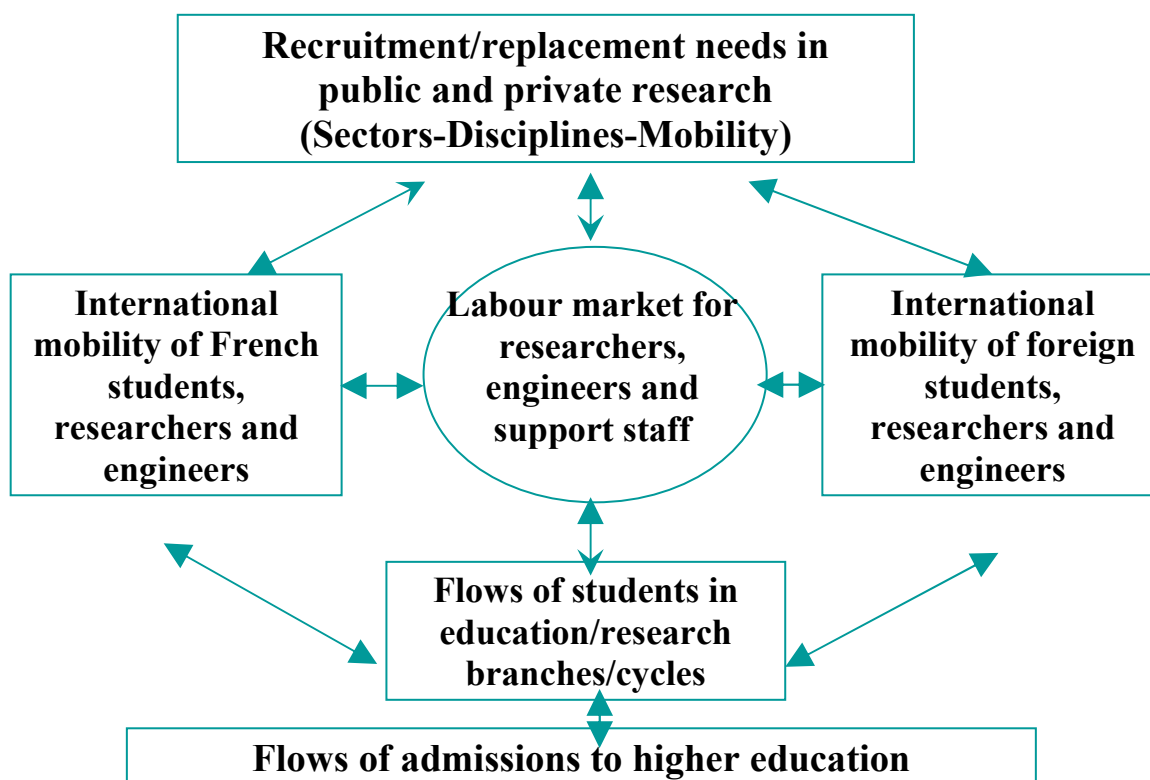
25. To grasp the impact of the degree of future attractiveness of France²⁷ to foreign students on research in the country, the project group adopted an analytical model (cf. figure 1) which shows the interaction between potential for research and innovation, labour market for scientific and technical personnel, education system and mobility of students and research workers.

26. For a detailed presentation of the project: [plan.gouv.fr](http://www.plan.gouv.fr), the first two summaries published, "Attractivité pour les étudiants étrangers et potentiel de la recherche en France". (June 2004) and "Pour une stratégie relative à la mobilité internationale des compétences en sciences et technologie" (March 2004) http://www.plan.gouv.fr/groupes/publications.php?id_project=13&id_theme=18

27. Several reports have been devoted to the question of the attractiveness of France, see in particular the Economic and Social Council report, Benoist (H. de), *Renforcer l'attractivité de l'économie française au service de la croissance et de l'emploi*, 2003; Charzat (M.), Hanotiaux (P.), and Wendling (C.), report to the Prime Minister on "*l'attractivité du territoire français*", 149 pages, July 2001; *l'entreprise et l'hexagone*, Joubert-Bomoard (A.), Lavenir (F.) and Wendling (C.), Report of the Inspectorate of Finance No. 2000-M-017-01, September 2000; Ferrand (A.), Information report for the joint information mission charged with studying all questions related to the expatriation of skills, capital and firms, No. 386, June 2001; François-Poncet (J.), Information report for the Committee on Economic Affairs and Planning on the expatriation of French youth, 388, June 2000; Ricout (G.), *l'expatriation: les français établis hors de France, acteurs du rayonnement international de notre pays*, Report to the Economic and Social Council, July 1999.

Figure 1. Analytical model adopted for the “Saraswati” project

International mobility of human resources in science and engineering and potential for research and innovation



M. Harfi-19/02/2004

26. Studies have been carried out to estimate needs for research and development personnel up to 2012-2013. These estimates take account of the increase in the average costs per researcher, mainly related to the rising cost of health and pensions. They also include possible tensions in the labour market for scientific personnel. In addition, simulations have been done, on the one hand to estimate the number of students taking post-baccalaureate studies and, on the other, to measure the impact of the variation in foreign student numbers in France on the potential higher education graduates capable of entering careers in research.

27. In 2000, foreign doctoral students numbered some 16,000, 26% of those enrolled, compared with over 78,884 in the United States and 26,143 in the United Kingdom (respectively over 28% and 35% of all students enrolled in 2001). During the 1990s, France experienced a significant decline in the number of foreign students, which also affected post-graduate education. Thus the number of doctorate degrees awarded to foreign students was 2,398 in 1999 compared with 3,183 in 1985, respectively 24% against 41.2% of the total number of doctorates awarded in France.

28. For doctoral students and French doctorate holders abroad and their rate of return to France after their education, only the statistical data published by the American agencies and data collected by the OECD provide some insight into the trend.²⁸ The lack of statistics and relevant indicators was recently

28. Terouane (D.), *Présence française en science et ingénierie aux Etats-Unis: cerveaux en fuite ou en voyage?*, CNRS Bureau, Washington, Scientific and Technical Mission, French Embassy, 1997; Ludovic

highlighted by the Academy of Technology.²⁹ According to reports by the National Science Foundation, the United States awarded over 55,000 doctorates in science and engineering in the period 1988-1996, of which over 43,000 were to students from Asia and 8,700 from Europe. Of the European students, 951 doctorates came from France. However, during the period the number of French post-doctorates were on average double the annual number of doctorates (respectively 271 and 139 for 1995 alone).

2) *Mobility of doctorate holders within Europe in the framework of the Lisbon Strategy*

29. “To make the EU the world's most dynamic and competitive economy” is the target fixed by Europe in the framework of the Lisbon Strategy. The creation of the European Research Area in January 2000³⁰ is central to the achievement of this goal. In addition, a quantitative target was fixed by allocating 3% of GDP to research and technology development. To achieve such a goal, it is necessary to increase not only funding, but also human resources in science and technology. The many estimates produced³¹ in the last two years show that Europe will need over 700,000 additional researchers.

30. The analyses underlying the definition of Europe’s plan of action cover four main objectives. *The educational system*, encouraging member countries to improve the effectiveness of their education system, in particular making science and technology more attractive to young people. *The research system*, encouraging countries, in addition to the necessary financial investment, to improve the transfer of knowledge to the economic sphere by developing public-private cooperation. *The labour market*, in particular researchers (doctorate holders). This means encouraging the employment of doctorate holders by improving career prospects. *Immigration and emigration policy*, underlining the importance of enhancing Europe’s attractiveness to foreign students and researchers³² and encouraging mobility within Europe.

31. International mobility of researchers is thus considered to be one means of developing the European Research Area³³, at the core of the Lisbon strategy. As underlined, moreover, by the conclusions of the European Council, it is a case of eliminating the barriers to the mobility of researchers in Europe and attract to Europe and retain high-level foreign researchers. The population of students and researchers, which was the subject of a communication from the European Commission in 2001³⁴ falls within the

(L.), and Raud (S.), *Présence française en technologie de l’information autour de la Baie de San Francisco et dans la Silicon Valley*, Embassy reports, Signes du Monde collection, July 2000; and Martin-Rouet (D.), and Sezec (E.), *Etat des lieux 2000 sur la présence française en science et ingénierie aux Etats-Unis: les cerveaux fous d’Amérique? pas vraiment...*, CNRS Bureau, Washington, Scientific and Technical Mission, French Embassy, 2001.

29. Relevant indicators allowing monitoring of the flows of young French scientists and engineers to other countries, in particular the USA, opinion of the Academy of Technology to the Minister for Research and New Technology, 18 December 2003.

30. COM(2000)6 of 18 January 2000.

31. “Increasing human resources for science and technology in Europe”, Report presented at the EC Conference “Europe needs more scientists” Brussels, 2 April 2004.

32. “Brain Drain – Emigration Flows for Qualified Scientists”, feasibility study on outflows of European scientists and engineers, project coordinated by MERIT, European Commission, October 2003.

33. “Researchers in the European Research Area: one profession, multiple careers”, Communication from the Commission to the Council and the European Parliament, COM(2003)436 final, 18/07/2003.

34. A Mobility Strategy for the European Research Area, communication from the Commission to the Council and the European Parliament, COM(2001)331 final, 20 June 2001.

broader context of defining common positions on the free movement of persons.³⁵ Actions have been undertaken since then, such as those included in the resolution adopted by the European Council on 11 November 2003 on the research profession and careers in the European Research Area.³⁶

32. To implement this policy, the European Commission has instruments designed to develop student mobility within Europe, in particular doctoral studies, and researchers (Erasmus Programme and Marie Curie Fellowships.³⁷). In addition, immigration measures are being prepared to develop mobility within Europe,³⁸ as well as attractiveness to foreign researchers. Finally, it should be noted that parallel to the implement of the Lisbon Strategy, the so-called Bologna process seeks to harmonise the higher education system at three levels, first degree, master and doctorate, which should stimulate mobility within Europe.

3) *International mobility of doctorate holders in (and to) the United States: attractiveness and dependency of the system of research and innovation*

33. The United States, like other countries such as Australia and Canada, has considerable needs for foreign scientific personnel to meet the demands of its national system of research and innovation. In some sectors of technology or scientific disciplines, the proportion of foreign personnel is over one third of the total number of scientists. During the 1990s, recruitment difficulties encountered in various sectors of technology also led the United States to adapt its immigration policy for this category of highly qualified workers.

34. Indeed, human resources management becomes a key issue for reflection, in particular looking ahead, on the future of the system of research and innovation in the United States.³⁹ As underlined in the conclusion of the National Science Board of the NSF⁴⁰, the United States continues to be the leading producer and exporter of high technology products and in terms of R&D spending. However, the current changes in economies and human resources make the future uncertain.

35. Another report, published on the theme "National workforce policies for science and engineering" also raises questions concerning the potential impact of the trend in mobility of scientific personnel, such as doctorate holders, on human resources in science and engineering in the United States.⁴¹ As the report underlines, that will depend on a combination of the following four factors:

35. "Principaux éléments des projets de positions communes relatives à la libre circulation des personnes" Doc. SEC(2001)538/7 of 11 April 2001; and "New European Labour Markets, open to all, with access for all", communication from the European Commission, COM(2001)116 final.

36. Cf. Note 30.

37. For a presentation of the trend in doctorate holders' mobility in Europe, see "European Doctoral Mobility", Dr Irving V Mitchell, DG Education and Culture, European Commission, Brussels, report prepared for the meeting of directors-general for higher education and presidents of rectors' conferences, Córdoba, Spain, 6-9 April 2002.

38. Second implementation report on "A mobility strategy for the European Research Area", Commission staff working paper, SEC(2004)412, 1 April 2004.

39. See, for example, the report "Graduate Education reform in Europe, Asia and Americas and international mobility of scientists and engineers: proceedings of an NSF Workshop", NSF00-318, J.-M. Johnson, 2000.

40. "Science and engineering indicators 2004", National Science Foundation, 2004.

41. "The Science and Engineering Workforce: Realizing America's Potential", National Science Board, 14 August 2003.

- Ageing of the population of scientists and engineers and outlook for departures and retirements in the next 20 years.
- The number of American higher education graduates, especially doctorate holders of science and technology.
- The level of needs and the growth in scientific employment.
- The attractiveness of the United States to foreign students and researchers in a framework of international competition.

36. Furthermore, at this stage in the analysis, it is essential to take an additional constraint into account: how to attract foreign students, scientists and engineers to the United States and encourage them to stay permanently without the proportion of them translating into over-reliance (currently 38% of scientists and engineers with doctorates in the United States are foreigners⁴²).

37. It should be underlined that the United States has far and away the most developed system of statistical information to identify flows and stocks of foreign doctorate holders and American doctorate holders abroad. Thus, an analysis of the international mobility of doctorate holders shows that in terms of net flows, the United States has a considerable advantage. Indeed, it is equally attractive to students studying for their doctorate as for established researchers. Data published by the OECD show that in 2001, 9,188 doctorates, *i.e.* 36% of doctorates in science and engineering in the United States, were awarded to foreign expatriates. Of these, 86% were in possession of temporary visas and 14% had resident status (green card). The doctorates awarded to foreign students break down between countries/geographical areas as follows: China 2,405; India 808; Korea 862; Europe 1,422, including 84 French and 138 British.

38. As we emphasised in the first section, access to the knowledge-based economy requires a high degree of international mobility of doctorate holders since this is beneficial to their training and career. For the United States, this mobility is also a means of strengthening its position in international scientific cooperation.⁴³ However, few American doctoral students or doctorate holders are mobile abroad in the long term. In 2002, 9,338 American citizens obtained a doctorate of whom only 289, or 3%, intended or had decided to work abroad.⁴⁴ Yet there are several initiatives in the United States and abroad to stimulate international mobility of American scientists. Is the United States in this area the exception that confirms the rule?

Conclusion: What indicators to guide public policies

39. International mobility of doctorate holders is a key element in their future career, but it is also an essential vector for the sharing of knowing and personal enrichment. Furthermore, international mobility is

42. This idea is not new, see "International Mobility of Scientists and Engineers of the United States – Brain Drain or Brain Circulation?" Jean M. Johnson and Mark C. Regets, Issue Brief 98-316, Division of Science Resources, NSF, 10 November 1998; "How much does the U.S. rely on immigrant engineers?", Lawrence Burton and Jack Wang, Issue Brief 99-327, Division of Science Resources, NSF, 11 February 1999; "Stay rates of Foreign Doctorate Recipients from US Universities, 1999", Michael G. Finn, Science and Engineering Education Program, ORISE, December 2001.

43. See especially the report of the National Board "Towards a more effective role of the US Government in international Science and engineering", NSB 01-187, 2003.

44. "Emigration of US-born S&E doctorate recipients", Joan S. Burelli, InfoBrief 04-327, Science Resources Statistics, National Science Foundation, June 2004.

inherent to scientific excellence, which requires interaction between researchers and more generally between teaching establishments and public and private research laboratories.

40. Based on the available statistics, it is difficult at present to give a precise answer to the questions posed by government decision makers. Thus it is almost impossible to compare flows and "stocks" of internationally mobile doctorate holders to infer trends in the "balance" of migration. Moreover, the existing statistics are mainly quantitative and do not allow an evaluation of "quality" and the "loss and/or gain" of potential due to the non-return of doctorate holders moving abroad.

41. In order to be able to conduct in-depth analyses of the internationality mobility of doctorate holders, the work of defining indicators and appropriate statistical processes should take the following six points into account:

- a) ***Mutualisation of statistics***: in this area the collection of harmonised data (by scientific discipline and sector of activity) at international level is paramount. No country can claim that its statistical data are exhaustive in this area.
- b) ***The different dimensions of the analysis of international mobility of doctorate holders***: immigration, labour markers, education systems, systems of research and innovation (doctoral education in particular), etc. This means that the statistics collected on doctorate holders must be useable in an integrated approach (harmonisation of classification by scientific discipline and sector of activity).
- c) ***Temporal dimension***: it is essential that indicators to distinguish the duration and periodicity of international mobility of doctorate holders. Some analyses would therefore require sample data.
- d) ***Doctorate holders motives to be internationally mobile and decision whether or not to stay in the host country***: some indicators should allow an understanding of the factors in doctorate holders' mobility, in particular their motives for mobility and staying, for a longer or shorter time, in the host country. In addition to the work of the OECD, research programmes could usefully be undertaken at international level by funding research networks on these issues.
- e) ***Structural and economic surveys***: the rapidity of the changes in the domain of international mobility of doctorate holders requires regular structural surveys complemented by economic surveys to identify possible reversals in the trend.
- f) ***Economic integration areas and international mobility of doctorate holders within and outside those areas***: is the development of international mobility within economic and/or political integration areas reflected in decreased international mobility outside the area? For example, could the development of mobility within Europe bring it on a convergent path towards a situation comparable to that of the United States where mobility of American doctorate holders is mainly between states and less internationally.⁴⁵ Even today and despite the development of academic mobility in Europe, the labour market in scientific personnel remains primarily national.⁴⁶

45. "Interstate migration patterns of recent science and engineering doctorate recipients", Allen Sanderson and Bernard Gudoni, Science Resource Statistics, National Science Foundation, NSF 02-311, February 2002. The same theme was the subject of a study in 1993.

46. See especially the article by Christine Musselin, "Towards a European academic labour market? Some lessons drawn from empirical studies on academic mobility", Centre de sociologie des organisations (CSO)-FNSP/CNRS.