A comparison between the French and the US scientific labour markets: academic vs. non academic jobs ?

Philippe Moguérou[1]

IREDU (CNRS-Université de Bourgogne, Dijon, France)

Second draft, April 2002

Abstract

In this paper, we try to understand the differences in the thesis-to work transition of Ph.D. graduates in science and engineering disciplines between France and the United States in the 1990s. Important quantitative and qualitative transformations in the scientific labour market have been observed on this period. An increasing number of doctorates has been awarded in the two countries since the mid-1980s whereas the number of "traditional" academic positions has declined. The socio-demographic transformations of the doctorate recipients, the development of post-docs and non tenured positions in the academic sector and the reinforcement of the industry-academic links are some of the other transformations that have affected the scientific labour market. What are the micro-economic consequences of these evolutions ? The scientific labour market was historically structured by the opposition between academic and non academic jobs. But, the evolutions we underlined above may have led to more complex patterns in the "school"-to-work transition for Ph.D. graduates. Human capital is still a key element in understanding the situations of individuals on the labour market, with the role played by individual characteristics. But, specific human capital potentially plays an increasing role for Ph.D.s in an integrated and more competitive environment. The development of individual competencies becomes therefore an element to take into account as well as other variables more specific to Ph.D.s. Empirically, we use micro data from a survey carried out by the French Centre on qualifications (Céreq) and from the Survey of Doctorate Recipients carried out by the National Science Foundation (NSF). We show that a number of variables has a similar effect on the probability of being out of the labour force or unemployed and on the probability of being employed as academics in the two countries (gender, financial support mechanisms for doctorate, fields of doctorate).

Keywords: professional labor markets, higher education, Ph.D.

JEL classification: J44, J24, I21.

---

[1] IREDU-CNRS, Université de Bourgogne, 9 av. Alain Savary, 21078 Dijon Cedex, France. Tel: +33-380-395-237, Fax: +33-380-395-479, E-mail: philippe.moguerou@u-bourgogne.fr. Or, until March 2002: SPRU, University of Sussex, Mantell Building, Falmer, Brighton, BN1 9RF, UK. Tel: +44-1273-87-7283, Fax: +44-1273-68-5865, E-mail: p.moguerou@sussex.ac.uk.
I would like to thank the participants to the 2001 ZEW conference in Berlin on unemployment, the participants to the 2001 IZA Summer School in Buch and my colleagues at IREDU and SPRU.

Introduction

The international comparisons in the higher education field are often complex. The institutional differences in the higher education and research systems, and more generally, the differences in the economic and social systems, make things difficult. And, last but not least, the availability and the comparability in the data among countries increase these difficulties. However, this type of comparison may also be very productive and interesting to assess the different factors that are likely to influence individual behaviour or to analyse the success or failure of public policies. In that perspective, we try to compare the labour market conditions of Ph.D. graduates between France and the United States. We attempt to assess the different factors, but also the common trends, that are likely to explain the thesis-to-work transition of Ph.D.s in science and engineering fields at the end of the 1980's and at the beginning of the 1990's.

Indeed, important quantitative and qualitative transformations in the scientific labour market have been observed on this period. These evolutions are often specific to the doctorate level, but some more general transformations that have affected the youth labour market since the 1980s have also had consequences on the Ph.D. labour market (Blanchflower and Freeman 2000, Ryan 2001). The debate about over-education is relevant to the doctorate level even if it had not been specifically studied at this level (Muysken and Weel 1999, Borghans and de Grip 2000, Cahuc and Postel-Vinay 2000, Dolton and Silles 2001).

Quantitative transformations that have affected the scientific labour market are essentially twofold: an increasing number of doctorates has been awarded each year since the mid-1980s and there has been a transformation in the composition of the pool of Ph.D.s available since then (females account for a greater portion and, in the USA, the number of minority recipients and the number of foreign-born recipients have increased); on the supply side, there has been a stagnation or a decrease in the number of "traditional" academic positions available.

The main argument which is able to explain these different patterns in the labour market situation is the evolution in the number of Ph.D. graduates who enter the labour force. There is a long tradition of economic studies that provide evidence of the cyclical behaviour of many professional labour markets, and particularly the engineering labour market. Some empirical regularities in the dynamics of occupational choice have been found in many fields (Freeman and Leonard 1978). At the theoretical level, many models have analysed the dynamics of occupational choice since the publication of the Freeman's book in 1971 (Drost 2000). The Freeman's original cobweb model (Freeman 1975, 1975a, 1989) has been criticized by Zarkin (1983, 1985) for its myopic wage adjustment processes. But even in introducing rational wage expectations in the model, cyclical behaviour persists. The second hypothesis can be eliminated either: if the individuals are mobile across sectors the model can still exhibits a cyclical phenomenon (Felderer and Drost 2000).

The oversupply or undersupply of Ph.D.s is an element to take into account. But, macro evaluations of the state of the scientific labour market are very difficult to make and their conclusions vary sometimes greatly from one report to another (Massy and Goldman 1995).

Many studies that attempted to assess the right number of scientists and engineers or to forecast the future shortages or over-supply of scientific manpower have been unsuccessful.[2]

Therefore, these quantitative elements are not sufficient to explain the labour market prospects of Ph.D.s, even if these factors are of great importance in some S&E fields. In that perspective, we test indirectly, and at the micro-economic level, the hypothesis of a over-production of Ph.D. graduates by including the fields of Ph.D. in our models.

Qualitative transformations include the development of post-docs and non tenured positions in the academic sector, the new forms of organizations of science, the reinforcement of the industry-academic links in the innovation system, the internationalisation of science and the increasing mobility of researchers (Carnoy 1998, Stephan 1999, OECD 2000).

What are the micro-economic consequences of these evolutions, quantitative and qualitative ? Our analysis is focused on the “young” Ph.D. graduates in science and engineering fields in France and in the USA. These young scientists and engineers are the core highly qualified manpower for whom these transformations of the scientific labour market are of great importance. The scientific labour market was historically structured by the opposition between academic and non academic jobs. But, the evolutions we underlined above may lead to more complex patterns in the “school”-to-work transition processes.

Human capital is still a key element to understand the situations of individuals on the labour market, with the role played by individual characteristics even at this high level of qualification. We integrate the socio-economic background of individuals with a complete set of variables.

Specific human capital plays potentially an increasing role for Ph.D.s in an integrated and more competitive environment. The development of individual competencies becomes therefore an element to take into account.

Finally, expectations of individuals or specific elements that characterize Ph.D. graduates are introduce in the different models.

The paper is organized as follows.

In section I, we assess the evolution in the supply and demand of Ph.D.s in the last two decades in France and in the USA. We use macro data form the French Ministry of Higher Education and Research and from the US Survey of Earned Doctorates (NSF) to follow the number of Ph.D.s awarded and the socio-demographic composition of the doctorate recipients. Then we attempt to explain these evolutions.

In section II, we present the micro data we use and some descriptive statistics about the employment of Ph.D. graduates. We estimate different models to assess the entry in the labour market of recent doctorate recipients.

---

[2] The difficulties of that type of planning are underlined for example by Pollack-Johnson *et al.* (1990) in the US and Beltramo, Bourdon and Paul (1996) in the case of France. Recently, an interesting attempt has been made to forecast the labour market for scientists and technologists in Europe (Pearson *et al.* 2001, Marey *et al.* 2001).

Section I. A similar pattern in the supply of doctorates in the two countries during the last two decades

A boom and bust phenomenon is generalized in the production process of Ph.D. graduates, even if there exists or has existed a positive trend in the number of doctorates awarded each year. For example, in the physics field in the USA, the first Ph.D was awarded around 1870. At the beginning of the 20th Century the number was about 10 per year, by 1930 about 100 per year, and by 1970, 1000 per year. Since then, the number of doctorates has remained "relatively" stable, at about 1,000 per year, with oscillations around this level.[3] The end of the golden age of science and probably the end of the academic expansion[4], led to new questions about the labour market prospects for Ph.D. graduates outside the academic sector. In that sense, that type of short-term oscillations are not without importance and may have important consequences on scientific labour markets. Especially if we consider, as many studies prove it, that the beginning in the career of an individual – and the conditions under which it is made – is an essential step in the following career development (hysteresis phenomenon). This short-term cyclical phenomenon has a strong influence on the labour market prospects of Ph.D.s. Here we focus our analysis on the last two decades during which we observe an increase followed by a decrease in the number of Ph.D. graduates in the two countries. Similar trends in the number of doctorates awarded are clearly visible.

Historical trends

In the USA, two main period of sharp increase in the total number of annual doctorates awarded by US universities can be displayed. 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.[5] The second period of steady increase began in 1986 and ended in the mid-1990s. This second wave of growth is explained in the 1980s 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.[6]

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

The growth is more important in France than in the USA. Between 1986 and 1996, the number of annual doctorates grew by 130% in France and by 33% in the USA. But in the two countries, most of the growth is concentrated between 1989 and 1994, with respectively an increase of 72.7% and 19.5%.

---

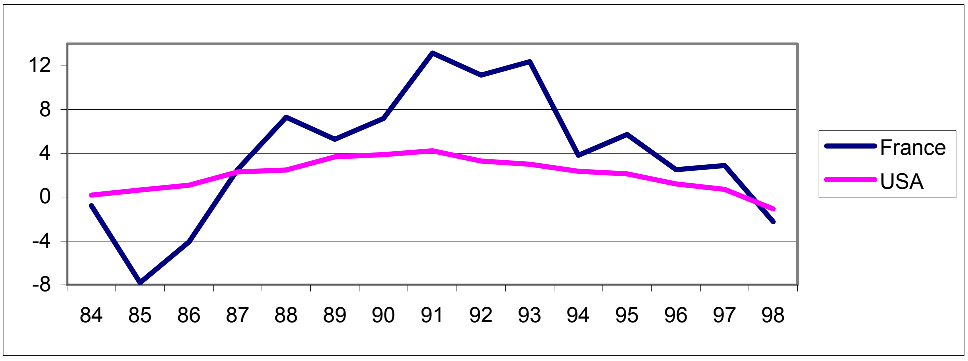
[3] Even if we have not to neglect the emergence and the development of other "new" fields.

[4] For various reasons: cutbacks in defence spending and, to a lesser extent, public spending, transformation in the innovation systems with increasing importance of the private sector, new rationale for public funding of science...

[5] This first upsurge reflected the impact of the cold war and the space race.

[6] Even if there is an overall increase of 0.8 percent in doctorates awarded between 1999 and 2000.

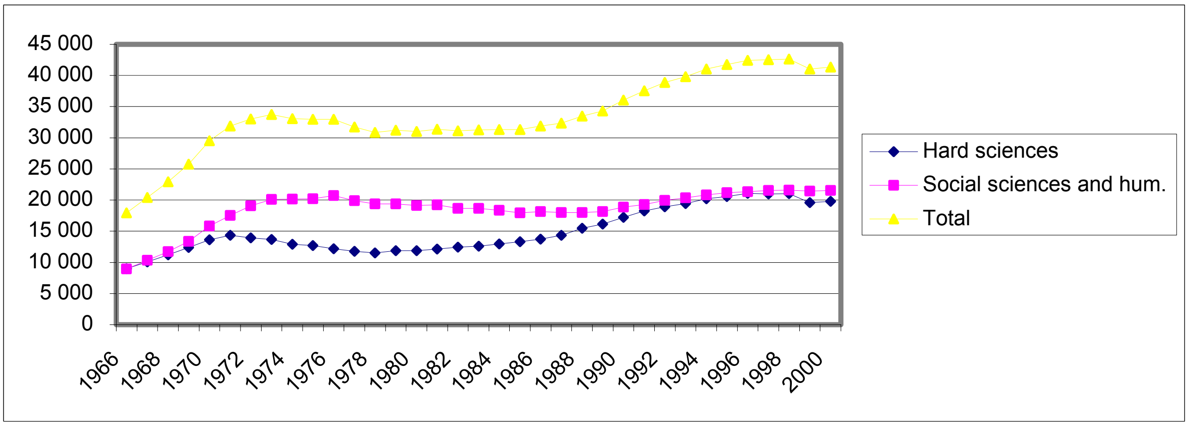
Figure 1. Annual percentage change in doctorates awarded in France and the USA



Source: Ministère de l'Education et Ministère de la Recherche (several years) and SED (2000).
Note: the growth rates are calculated on 3 years moving average series (to eliminate the over-volatility in the French case).

By broad fields[7], the two countries offered similar patterns in the number of Ph.D.s annually awarded. Broadly speaking, in the "hard" 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 growth.

Figure 2. Annual number of doctorate recipients in the USA (1966-2000)



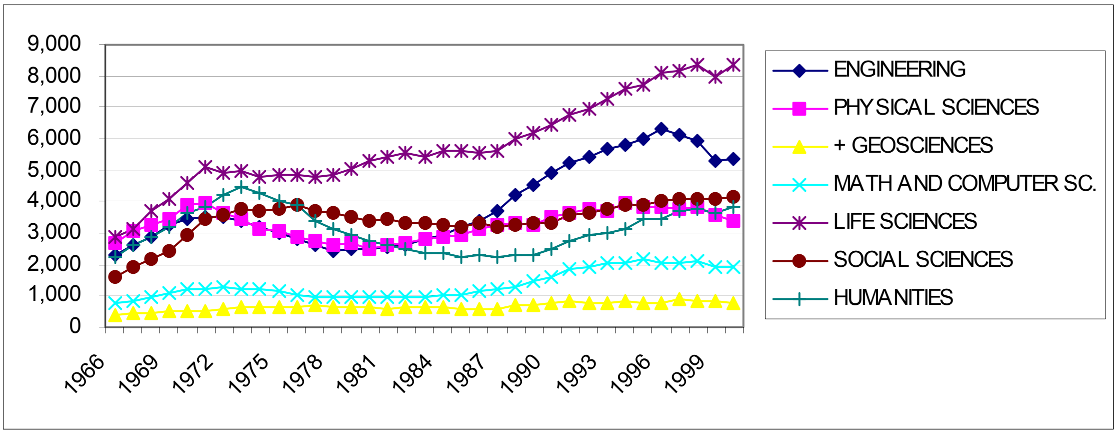
Source: SED (2001), Doctorate Records File. The Survey of Earned Doctorates is conducted annually by the University of Chicago National Opinion Research Center for six Federal sponsors (NSF, NIH, USED, NEH, USDA), NASA).
Note: our calculations. The number of doctorates awarded in the "hard" sciences is the sum of the five broad fields engineering, physical sciences, geosciences, maths and computer sciences and life sciences. The number in the social sciences and humanities is the sum of the social sciences, humanities, education and the other fields that remain.

---

[7] The choices of classification and terminology are difficult. Therefore, we will use alternatively the terminology of the NSF in the SED and a French terminology. But, in the hard sciences we will include the physics, chemistry, earth sciences, mathematics and computer sciences, the engineering field and the life sciences.

In the USA, the computer sciences, the mathematics and the physics-astronomy are the three fields with the most important growth between the mid-1980s and the mid-1990s. The growth in the engineering field was also particularly important. The behaviour in the life sciences is more specific: the growth is less important at the end of the 1980s[8], but it continues until the end of the 1990s (for more details, see the detailed tables in the appendix). Between the 1999 and 2000 academic years, the increase in the life sciences was of 4.7 percent after a small decrease between 1998 and 1999.

Figure 3. Number of doctorates awarded by broad fields in the USA (1966-2000)



Source: SED (2001).
Notes: some "minor" fields are excluded from our grouping.

In France, similar patterns are observed. The increase in the hard sciences is important 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 important in the life sciences than in the other scientific fields.

Table 1. Annual number of doctorate recipients in France (1992-1999)

	92	93	94	95	96	97	98	99	99/92	96/92	99/96
Maths-comp	683	740	846	792	898	886	845	769	12.6	31.5	-14.4
Physics-eng	2121	2283	2532	2324	2864	2764	2636	2469	16.4	35.0	-13.8
Earth sci.	418	410	439	417	499	493	436	392	-6.2	19.4	-21.4
Chemistry	1113	1094	1197	1122	1150	1120	1031	965	-13.3	3.3	-16.1
Life sci.	1672	1857	1977	1946	2002	2070	2033	1882	12.6	19.7	-6.0
Sub-total	**6007**	**6384**	**6991**	**6601**	**7413**	**7333**	**6981**	**6477**	**7.8**	**23.4**	**-12.6**
Humanities	1404	1587	1987	1756	2020	2096	1903	2126	51.4	43.9	5.2
Social sci.	1174	1326	1620	1304	1537	1652	1698	1638	39.5	30.9	6.6
Total	**8585**	**9297**	**10598**	**9661**	**10970**	**11081**	**10582**	**10241**	**19.3**	**27.8**	**-6.6**

Source: *Rapports sur les études doctorales* published by *Ministère de l'Education Nationale* and *Ministère de la Recherche* (various years).
Note: last three columns, growth rates between the respective years, in percentage.

[8] In the life sciences field, the biological sciences and the health sciences concentrated all the growth. A decline in the number of doctorates is observed for the agricultural sciences on the whole period. And differences exist between biomedical and nonbiomedical sciences. All the growth has been concentrated in the biomedical fields. Cf. National Research Council (1998).

Table 2. Annual number of doctorate recipients in the USA (1992-99)

	92	93	94	95	96	97	98	99	99/92	96/92	99/96
Maths-com	1927	2026	2021	2187	2043	2035	2102	1935	0.4	6.0	-5.3
Physics,eng	6975	7242	7514	7660	7981	7713	7516	6768	-3.0	14.4	-15.2
Earth sci	824	789	852	807	807	900	838	824	0.0	-2.1	2.1
Chemistry	2214	2137	2257	2162	2148	2147	2219	2134	-3.6	-3.0	-0.7
Life sci	7115	7395	7739	7918	8255	8325	8551	8126	14.2	16.0	-1.6
Sub-total	**19055**	**19589**	**20383**	**20734**	**21234**	**21120**	**21226**	**19787**	**3.8**	**11.4**	**-6.8**
Humanities	4444	4482	4744	5061	5116	5436	5511	5468	23.0	15.1	6.9
Soc sci.	15391	15730	15907	15948	16064	15993	15939	15885	3.2	4.4	-1.1
Total	**38890**	**39801**	**41034**	**41743**	**42414**	**42549**	**42676**	**41140**	**5.8**	**9.1**	**-3.0**

Source: Survey of Earned Doctorates (various years). Our calculations.
Notes: we operate fields grouping to attempt to obtain comparable results with the French one. In particular, 'Physics,eng' include physics and engineering and 'Social sciences' include social sciences, education and other professionals. Last three columns: growh rates.

The combination of public policies and social and economic incentives explains the increase in the number of doctorates

Why this increase in the supply of doctorates ? Two main explanations are developed in the following sections: the transformations in the socio-demographic composition of the applicant pool and the evolution in the institutional environment of the research activity.

Socio-demographic evolutions of the applicant pool

Here, we consider different causes that have played a role in the rise in the number of doctorate recipients in France and in the United States. These factors are more or less relevant for the two countries:

- An increase in the scientific immigration, and particularly from the temporary non-immigrant visa programs. The magnitude of the surge in production of Ph.D.s has come essentially from the temporary visa sector since the mid 1980s, with smaller increases and fluctuations among permanent immigrants and US citizens. The percentage of non-US citizens on temporary visas among doctorate recipients has increased from 12% at the beginning of the 1980s up to 26.2% in 1992. This figure has remained relatively stable since then, at about 22-23%, even if it is on the increase for last two years (24.4% in 2000). Therefore, most of the net growth in the number of Ph.D.s after 1985 was due to an increased number of foreign students with temporary student visas.[9] Some authors note that the immigration Act of 1990[10], which specified categories of individuals seeking to immigrate who had

[9] This is a controversial point in the American context. See North (1995), Carnoy (1998), Weinstein (2000).

[10] The Congress tripled the number of permanent visas for highly skilled immigrants after an un-published controversial study by the NSF. In 1989, Erich Bloch, then-Director of the National Science Foundation, claimed that unless action was taken, there would be a cumulative shortfall of 675,000 scientists and engineers over the next two decades. The claims were reinforced by a widely publicized study by Richard Atkinson, president of

specific skills and gave them added consideration[11], has increased the number of doctorates in the USA. The percentage of doctorate recipients permanent non-US citizens varied between 4 and 5% during all the 1980s. This figure increased up to 10.6% in 1995. It has been decreasing since then to 4.9% in 2000.[12] But, this legislation does not directly apply for non-US citizens with temporary visas. However, the global context of the end of the 1980s, that favours the arrival of new temporary immigrants, may have had important consequences on the scientific labour market - particularly on post-doctorate positions[13] - or may have been a signal for new Ph.D. immigrants. The percentages of doctorate recipients non-US citizens has increased since the beginning of the 1980s.[14] This increase is both due to the temporary residents portion, and to a lesser extent, to the permanent residents component, and may has been the result of a transformations in the legislation. The proportion of non-US residents varied greatly from one field to another. This proportion is particularly high in the "hard" sciences field. In France, 21.1% of doctorate recipients were foreigners in 1999. This proportion has been decreasing (up from one third) since the beginning of the 1990s. Among the doctorate recipients from abroad, the proportion of students from Europe has remained relatively stable (at about 16%) and the proportion of students from the North of Africa has decreased on the same period (from about four tenth to one quarter).

- An increase in the number of doctorates earned by US minority groups. Doctorates awarded to US minority race/ethnic categories increased much more in the 1990s than in the previous decades.[15]

---

the American Association for the Advancement of science. Some authors talked about a "seriously flawed study" and that "there was really no basis to predict a shortage" (Weinstein 2000).

[11] This Act gives university employers special privileges in hiring non-citizen faculty members.

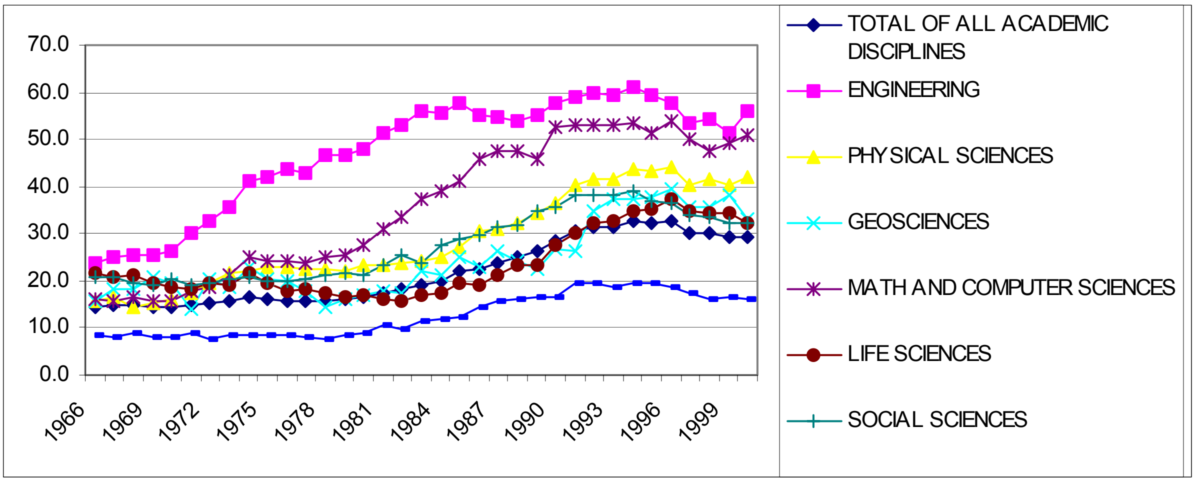
[12] In the whole science and engineering field, a decline in foreign graduate enrollment in U.S. universities occurred from 1993 to 1996.

[13] These consequences will depend on the stay rates after the completion of the Ph.D.. "Historically, about one-half the foreign students who earned S&E doctoral degrees within U.S. universities planned to locate in the United States, and a smaller proportion, about 40 percent, had firm offers to do so. In the 1990s, however, foreign doctoral recipients from Asia, Europe, and North America increasingly planned to stay in the United States and received firm offers to do so. By 1997, 69 percent of foreign doctoral recipients in S&E fields planned to stay in the United States following the completion of their degrees, and 50 percent had accepted firm offers to do so." (Science and engineering indicators 2000, Chapter 4, p.34). Finn *et al.* (1995), by combining data from multiple sources, estimate the gap between individuals who say they have plans to leave but never do so, and individuals who planned to stay, and effectively stay. See also Finn (1999), and for an international comparison, Auriol and Sexton (2001).

[14] The influx of foreign Ph.D.s does neither appear to be the sudden result of one-time political events such as the breakup of the Soviet Union and the post-Tiananmen Square exodus from China.

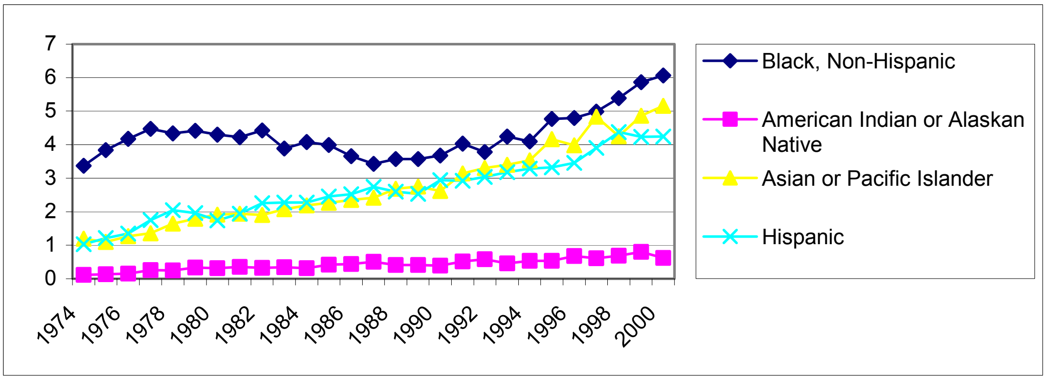
[15] This rise is general at the different levels in the S&E fields: "In 1989, American Indians, Blacks, and Hispanics received 9.8% of all science and engineering bachelor's degrees awarded to U.S. citizens and permanent residents. By 1995 these underrepresented minorities received 13.5% of such degrees awarded to U.S. citizens and permanent residents. The underrepresented minority share of S&E bachelor's degrees has increased as the number of such degrees has grown. There has been a stable trend toward increased bachelor's degree production in S&E for underrepresented minorities with increases of over 58.0% for Blacks, 66.5% for Hispanics and 71.7% for American Indians between 1989 and 1995. By contrast, degrees awarded to white, non-Hispanic U.S. citizens and permanent residents have increased by only 10% during the same time period." (Malcom *et al.* 1998). See Hill (1997) and Tsapogas (2001).

Figure 4. Percentage of doctorate recipients non US-citizens by broad fields



Source: SED.
Note: proportion of doctorate recipients non US-citizens (on temporary or permanent visas) among the doctorate recipients with known citizenship.

Figure 5. Percentage of doctorates earned by minority US citizens (1974-2000)



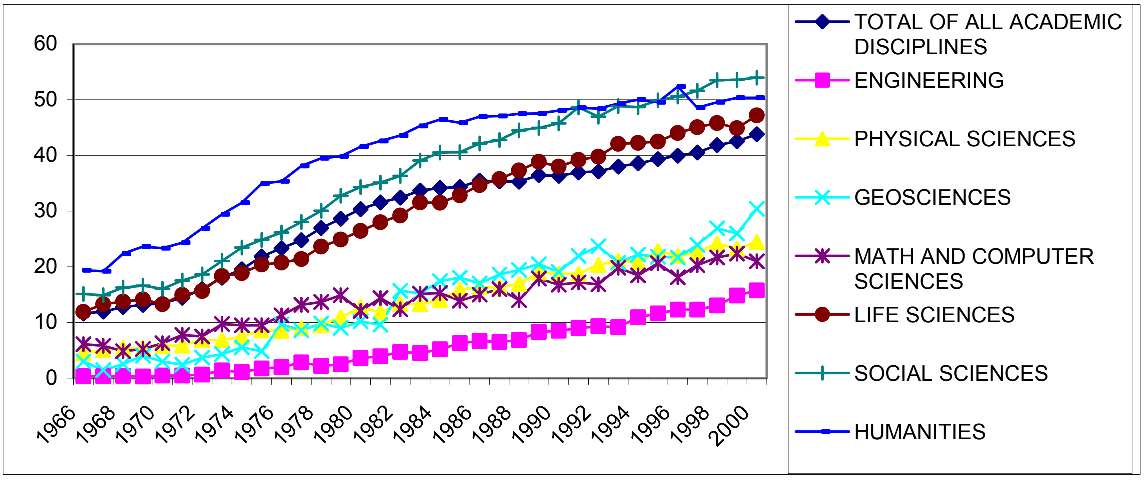
Source: SED.
Note: as percentage of the doctorates earned by US citizens.

- An increase in the female attendance of doctorates. Since the 1960s, there has been a clear increase in the number of doctorates earned by women. Long-term trends in the proportion of female doctorate recipients are observable in all disciplines. Females received today 44% of all doctorates, up from 12% at the end of the 1960s. The increase has been of 7.4 percentage points (all fields) since 1990 after a stagnation at the mid of the 1980s. But the proportion varies greatly from one scientific discipline to another.[16] In France, the proportion of females receiving Ph.D.s has also increased, from 30% at the end of the 1980s up to 40% in 1999. In the life sciences, social sciences, humanities and chemistry, more or less half of

[16] More generally for an analysis of women in the academia, see Ward (1999).

Ph.D. recipients are women. Lower percentages are found in mathematics, computers sciences, physics and engineering (around 20%).[17]

Figure 6. Percent of female doctorate recipients by broad fields (1966-2000)



Source: SED.

- In the context of a weak economic growth at the beginning of the 1990s in France, the incentives for students to go on studying are high because of the temporary depressed labour market. As Gustman and Steinneier (1981), Light (1995) or Card and Lemieux (2000) underlined, students tend to stay in school longer in a depressed labour market, even if it is far from being the only determinants (Card and Lemieux 1997). The slow growth in the R&D expenditures and the slow growth, or the decline, in the public expenditures provided low labour market prospects for students during all the first half of the 1990s. Students who graduated with a *maîtrise*, with a *DEA*, or even with a engineering schools diploma, at the beginning of the 1990s had a lot of difficulties when they started looking for employment. The 1993 recession was particularly intense and the economic growth was slow during nearly all the decade. In the USA, the number of applicants to doctorate is probably less sensitive to the macro-economic conditions because the overall unemployment rate of post-graduates in S&E fields is lower. However, the 1991 recession may have had an effect on the number of applicants.

The institutional environment of the research activity

Public policies have an impact on the supply of doctoral programmes but the research sphere is also relatively autonomous in the determination of the number of Ph.D.s. Two other main factors explain the increase in the number of doctorates:

[17] These percentages have been decreasing for two or three years now in mathematics, computer sciences and chemistry (with a decrease of 2 to 5 percentage points). The same thing was observable last year (1999) in physics and engineering (from 25 to 22 percent).

- Since the beginning of the 1980's, public policies have attempted to develop research in the fight of the technological competition at the international level. The development of higher education and research was seen as a major determinant of long-term economic growth. The number of scientists and researchers seemed to be less important than in the other major OECD countries. A lack of scientific manpower could therefore slow down economic growth. In France, as in many other countries (OECD, 1991), numerous studies which attempted to forecast scientific manpower requires concluded at a future shortage in engineers and scientists. Public responses to this anticipated shortage in the number of researchers were conducted in many ways. The funding of thesis have been developed since the mid-1980's[18] and we assist to a diversification of the funding sources for Ph.D. students. Education and research policies attempted to develop scientific departments in universities and doctoral schools have been implemented. Another major goal of public policies was to stimulate relationships between public research and industry. In the new context of innovation characterised by the importance of knowledge diffusion and industrial innovation, different measures were taken to promote research in the industry: *Cifre*[19] Ph.D.s were created in 1981 to encourage young researchers to integrate industrial firms, public funding for research and development... But the impact of these public policies on the number of Ph.D. awarded in France is difficult to assess. One can simply says that the impact is positive but one can not say to what extent.

- The institutional environment of the university[20], and specifically the asymetric relations between Ph.D. students and supervisors, tend to increase the incentives for students to make a thesis. The supervisor attempts to develop his scientific visibility in hiring Ph.D. students. But the Ph.D. student will be rewarded by the help that his supervisor will give him in attending academic position.[21] More generally, Massy and Goldman (1995) found that three of the main factors used to determine Ph.D. program size are the number of faculty advisors available, the number of teaching assistants needed for staffing classes and the amount of research money available for funding assistantships.[22] In the American context of the 1980 in some fields[23] and in the French context of the 1990s of an easier access to funding sources, this phenomenon may have played an important role.

---

[18] The number of grants from the ministry of higher education and research doubled. These grants (approx. scholarships) allocated for three years by the Ministry allow the students to complete the research for a thesis.

[19] *Cifre* (*Convention industrielle de formation par la recherche*): Ph.D. Graduates who take part in an industrial agreement on training through research. Ph.D.s that are funded and employed by a private firms to conduct their theses.

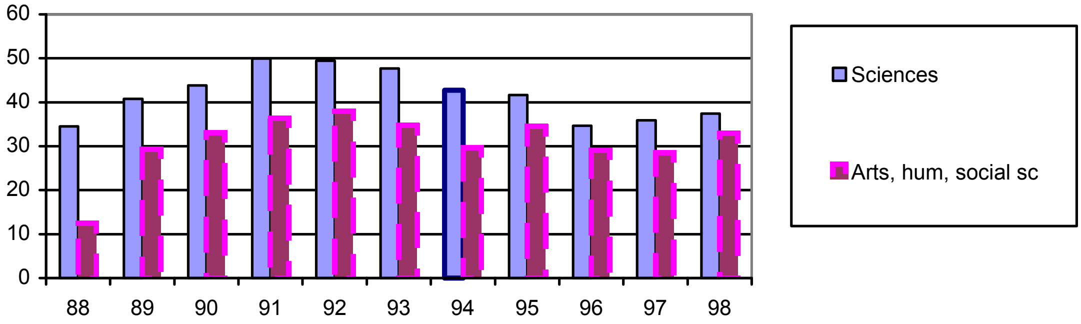
[20] Actually, the Ph.D. is the only diploma that gives an access to academic positions.

[21] See for example Stephan and Levin (1997) for an analysis of the Ph.D. student-supervisor relations in terms of the implicit contract theory.

[22] Massy and Goldman (1995) note that "[…] faculty express concern about the labor market for Ph.D.s and will do what they can to place their own students—but their concern does not lead to adjustments in doctoral student intakes. Faculty tend to believe that more scientifically-trained manpower is better than less, and that job opportunities will materialize somehow. In any case, the department's short-run requirements for inexpensive research and teaching labor, and the desire of faculty to replicate their own skills, is of stronger relevance to admissions decisions than the more abstract and distant concept of labor market balance."

[23] For the mathematics field, see Davis (1997).

Figure 7. Percentage of theses funded by the Ministry of Research (1988-1998)



Source: Ministry of Education and Research. Percentage of *allocation* (grant, approx. scholarship) allocated by the Ministry of Higher Education and Research.

Section II. The labour market for Ph.D.s: academic *vs.* non academic positions

What are the consequences on the scientific labour market of this increase in the number of Ph.D.s awarded and of this transformation in the population receiving doctorates ?

The academic sector is the traditional sector of employment for Ph.D.s, especially in France[24] but also in the USA. But in the context of slow growth in the public R&D expenditures, the academic jobs grew less than the number of Ph.D. available.[25] Thus, some main consequences can be expected from this new situation, with four mechanisms of adjustment; and these mechanisms are not independent from one to another:

- An increase in the unemployment rates or a decrease in the participation rates for Ph.D. graduates. Or more generally, the labour market conditions may be more difficult for recent Ph.D. graduates in some disciplines.

- An increase in the number of post-doc positions, as waiting positions. If the main goal of Ph.D. graduates is to become academics, some of them will choose to wait a few years in this type of positions, trying to enter the academic sector. The main

[24] The French higher education system is divided between the universities and the Grandes Ecoles. The traditional destination of the Grandes Ecoles graduates is the private sector, or the State as civil servants. Ph.D. graduates from universities are traditionally employed in the public and academic research sectors (universities as enseignants-chercheurs (academics) and CNRS, the biggest public research agency).

[25] The decrease at the US federal spending on R&D has been fueled since the mid 1980s by declining expenditures on R&D for defense. Federal civilian expenditures for R&D, which were relatively stable in the early 1980s in constant dollars, have increased in the late 1990s. The sector that has enjoyed the largest increase has been spending on health related R&D, especially expenditures funded through the National Institutes of Health (National Science Board 2000). But, between 1990 and 1994, state expenditures for prisons and welfare increased while those for elementary and secondary education remained constant and the percentage for higher education decreased from 14% to 12.5%. The student-faculty ratio has moreover rather has deteriorated.

advantage for the universities is to employ qualified manpower at low cost, on non tenured positions.

- A decrease in the earnings of Ph.D. graduates due to the increased competition between Ph.D.s. If market-clearing mechanisms operate, an increase in the supply of doctorates may result in a decrease in the wages of individuals, other things equal. However, wages are able to vary greatly from one sector to another.

- The development of "new" jobs outside the academia and specifically the development of research positions in the private sector But it may also appear an increase in the number of jobs outside the research sector, public or private (exit from the research system). Some individuals may like to be employed on posts not related to their doctorate and for which they are not really prepared.

We try to understand the emergence of these new situations with two surveys, one for the French case, and the other for the USA case. We focus our analysis on the characteristics of individuals that are likely to influence the entry in the labour market. We are not able to compare cohorts over a long period, so we study the determinants that explain the entry in the labour market.

Selected samples and descriptive statistics

We select two samples of "young" Ph.D. graduates in the two countries that are relatively similar.[26]

For the United States, we merge two samples from the Survey of Doctorate Recipients carried out by the NSF. The first one, from the 1993 SDR, is constituted of individuals who awarded doctorate in S&E fields between 1985 and 1990, and less than 45. The labour market situation of these individuals is examined in April 1993. The second one, from then 1997 SDR, is based on individuals who granted doctorate in S&E fields between 1990 and 1994, less than 45. For those one, the labour market situation is examined in April 1997. We have 7181 individuals in the 1993 sample and 5884 in the 1997 sample. So, we assess the situation of those individuals between three and seven years after the completion of their Ph.D..

For France, we use a survey carried out by Céreq in 1999. We select a sample of French Ph.D. graduates in S&E disciplines[27] who completed their thesis in 1996. We can follow the situation of these individuals on about three years. Here, we consider their labour market situation in March 1999.

---

[26] We do our best in selecting the different samples to attempt to make them comparable. But, due to inherent differences in the surveys, this selection procedure is not optimal.

[27] The typology of disciplines is different in France and the USA. However, we try to select the most appropriate disciplines to make the comparison possible. In the Céreq survey we exclude individuals with a Ph.D. in arts and humanities but keep the individuals with a doctorate in social sciences. The SDR survey does not include individuals with arts and humanities doctorates, but it includes those with a diploma in social sciences along with the definition of the S&E field.

Table 3. Samples of Ph.D. graduates selected from the Surveys of Doctorate Recipients

	Maths and computer sciences	Life sciences	Physical sciences	Social sciences	Engineering	Total
			1993 survey			
Male	87	866	249	620	181	2003
Female	289	1344	852	640	2159	5178
Total	376	2210	1101	1160	2334	7181
			1997 survey			
Male	129	939	282	699	211	2260
Female	255	1120	696	522	1031	3624
Total	384	2059	978	1221	1242	5884

Source: SDR 1993 and 1997. Our samples.

Table 4. Samples from the 1999 Céreq survey

	Mathematics and physics	Chemistry	Computer sciences	Engineer.	Earth sciences	Life sciences	Social sciences	Total
Male	189	115	94	135	27	117	133	810
Female	69	122	22	41	22	147	133	556
Total	258	237	116	176	49	264	266	1366

Source: Céreq 1999. Our sample.

The unemployment remains relatively limited in the USA

The overall unemployment rate for US Ph.D.s in science and engineering is low, compared to the overall unemployment rate in the US economy. By comparison with the US situation, French Ph.D.s have lower labour market prospects.

In our samples, we compute the percentage of Ph.D.s who are out of the labour force and the unemployment rates. We give the results for the two merged samples in the following table. Unemployment rates and labour force participation rates vary little among major fields, at some notable exception. Differences among males and females are observed for the participation rates and, to a lesser extent, for the unemployment rates. In the table 6, we give the unemployment rates by detailed disciplines and for we distinguish between the two cohorts. The highest unemployment rates are observed in disciplines related to physics and chemistry.[28] An improvement in the situation of Ph.D. graduates in physics is observed between 1993 and 1997 whereas an increase in the unemployment rates of Ph.D.s in chemistry is notable. Globally the unemployment rates are relatively stable between the two periods.

[28] This result is coherent with the unemployment rates calculated with surveys conducted by professional societies. These surveys were coordinated by the Commission on Professionals in Science and Technology on 14 disciplines. The unemployment rates of Ph.D. graduates in 1996-97 observed in 1998 were the highest for Ph.D.s in chemistry and biochemistry (respectively 4.6 % and 4.0%) and Ph.D. graduates in earth and space science (3.9%).

Table 5. Labour force status of the US two cohorts

	Maths and computer sc.	Life sciences	Physical sciences	Social sciences	Engineering	Total
			Unemployment rates			
Female	1.4	1.3	2.8	1.1	1.1	1.4
Male	0.0	0.9	1.2	1.0	0.9	0.9
			Labour force participation rates			
Female	99.1	94.4	95.3	95.9	94.1	95.2
Male	99.6	98.4	98.6	99.3	99.5	99.0

Source: our sample selected from SDR 1993 and SDR 1997. Rates based on ILO standards.

Other measures of the labour market conditions more adapted to the highly educated population as Ph.D.s can be used. We compute the involuntary out of field and part-time rates (IOFPT). The first component of this rate is constituted by individuals who declare that their jobs are not related to their Ph.D. The second component is made of individuals who involuntarily work part-time. We add these two components and calculate then IOFPT rates – as percentage of individuals who are employed – by disciplines for our tow cohorts of recent Ph.D. graduates. The highest IOFPT rates are observed in the physical sciences – particularly in physics and chemistry – and in some social sciences. The results show that the IOFPT rates and the unemployment rates move in opposite directions between 1993 and 1997 in a number of disciplines.

Table 6. Unemployment rates and IOFPT rates for the two US cohorts by detailed disciplines

	Unemployment rates 1993	Unemployment rates 1997	IOFPT 1993	IOFPT 1997
Computer and maths sciences	0.5	0.3	4.0	6.3
Biological sciences	1.0	1.2	4.0	5.1
Other Life & Related Sciences	0.7	1.3	5.8	4.3
Chemistry, except Biochemistry	1.1	2.3	6.7	8.4
Physics and astronomy	2.5	1.2	8.1	16.1
Other physical sciences	1.6	0.5	6.3	8.0
Economics	1.8	0.6	2.3	1.8
Psychology	0.8	0.8	4.1	4.1
Sociology	1.9	1.5	7.6	8.5
Other Social Sciences	0.6	1.5	8.6	12.6
Chemical Engineering	1.9	2.0	6.7	5.6
Civil Engineering	1.0	0.0	2.0	6.3
Electrical, Electronics	0.9	0.9	4.2	7.8
Mechanical Engineering	0.9	0.0	4.3	7.3
Other Engineering	0.5	1.1	3.8	5.7
Total	1.0	1.1	4.9	6.5

Source: our samples.
Note: IOFPT: involuntary out of field and involuntary part-time rates. See text for details.

Labour market prospects are lower for the French Ph.D. graduates. Labour force participation rates are high and few differences appear between disciplines. The unemployment rates are high and are concentrated in some scientific fields.

Table 7. Labour force status of 1996 French Ph.D. awarded doctorates in March 1999

	Maths and physics	Chemistry	Computer sciences	Engineer.	Earth sciences	Life sciences	Social sciences	Total
				Unemployment rates				
Male	4.9	8.4	2.4	7.7	14.3	10.3	5.1	6.5
Female	10.7	19.5	0.0	6.4	16.7	11.8	9.7	11.6
				Participation rates				
Male	95.4	96.3	96.9	96.	90.3	97.0	100.0	96.5
Female	96.2	94.3	96.3	94.0	96.0	95.0	95.0	94.8

Source: Céreq 1999. Our sample.

The more common experience of post-doc

The total number of post-doctorates has increased steadily for the last thirty years in the USA, from 19,000 in 1982 up to 40,000 in 1999. The post-doc positions are almost concentrated in three major fields: life sciences, physical sciences and engineering. These three fields account for 93% of all the post-docs appointments in 1999. Historically, life sciences and physical sciences are the two fields with the highest rate of post-doc use. However, during the last years, a more surprising increase is clearly visible in the engineering field. But, the upward trend is the most important in the life sciences, with a pool of post-doctorate fellows now approaching 30,000. “In 1995, as many as 38% of the life-science Ph.D.s—5–6 years after receipt of their doctorates—still held postdoctoral positions or other nonfaculty jobs in universities, were employed part-time, worked outside the sciences or were among the steady 1–2% unemployed” (National Research Council 1998 p.4).

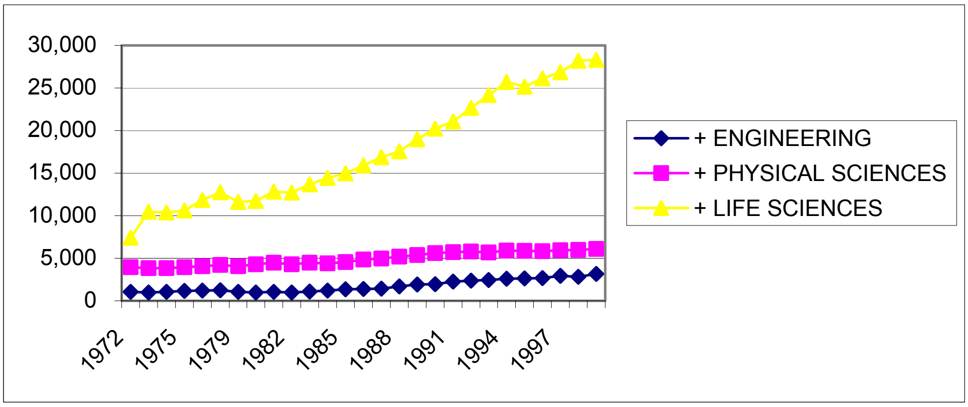
Temporary residents account for an increasing portion of these post-doctorate positions, form 33% in 1979 up to 53% in 1999. In the market for post-doc, the USA has become the most attractive place to go for young talented researchers.

Thus, the experience of post-doc has become more common among cohorts of Ph.D. graduates for the last three decades. The NSF reports that “the percentage of all S&E Ph.D.s who ever had a postdoc position has risen [...] from 25 percent for the 1965-66 graduation cohort to 42 percent for the 1993-94 cohort” (Regets 1998 p.1). In the biological sciences, physics and engineering, the corresponding percentages are respectively, 39% to 71%, 29% to 72% and 8% to 28%.

A report from the Association of American Universities (1998) underlined that some Ph.D.s become “career postdocs”, taking more than five years in postdoc positions. Some of them face the uncertainty of that job.[29] But, the lack of good and representative national data on the post-doc situations limit the analysis that can be undertaken.

[29] Many articles in scientific journals like Nature or Science have expressed concerns about the situation of post-doctorates during last years. See for example, Balter and Normile (1999), Maresi and Cerny (1999), Normile (1999), Magner (1998), Schneider (2000)...

Figure 8. Number of post-doctorates in the USA in three disciplines (1972-1999)



Source: NSF-NIH Survey of Graduate Students and Postdoctorates in Science and Engineering, NSF Division of Science Resources Studies.

In France, the post-doctorate 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-doc in France and the internationalisation of science have increased the number of French Ph.D.s seeking post-doc positions abroad. North America and especially the USA is the preferred destination of French Ph.D.s. In our sample, three years after the completion of the doctorate, one fifth of individuals are still in post-doc positions with great disparities among disciplines. One third of them are academics[30] (civil servant, tenured, employed for life). Another one third is employed in the private research sector with permanent position. The remaining of individuals – about one fifth – are employed in under-qualified positions.[31] We observe that the employment composition for recent French Ph.D. graduates is relatively close to the one for the US Ph.D. graduates (see below).

Table 8. Types of employment for French Ph.D. graduates (in percentage)

	Maths, Phys	Chemistry	Computer sciences	Engineer.	Earth sciences	Life sciences	Social sciences	Total
Academics	39.7	23.8	32.9	30.6	43.3	30.3	55.9	36.7
Private scientists and engineers	32.0	43.4	50.6	57.0	26.7	16.4	21.8	33.4
Post-doc positions	17.5	21.7	12.1	6.6	23.3	40.0	10.1	19.6
Under-qualified jobs	10.8	11.2	4.4	5.8	6.7	13.3	12.3	10.2

Source: our sample from Céreq 1999. Percentage among the individuals who are employed. This decomposition is made with a re-codification of the jobs described by the individuals in the database.

[30] here defined as *maître de conférences* or *chercheur au CNRS* (or an equivalent job in a public research institution).

[31] For example, employed as blue collar, teacher in the secondary education…

Main results: USA

A majority of doctorates is traditionally employed in the academic sector. But today in the USA, it is only the case of one half of Ph.D. graduates (Table 9).

We study the situation of Ph.D. graduates who completed their doctorate on the period 1985-1989 and those who completed their Ph.D. between 1990 and 1994. We observe the situation of these individuals respectively in April 1993 and April 1997.

Table 9. Employment sector among US Ph.D.s (in percentage)

	Maths and computer	Life sciences	Physical sciences	Social sciences	Engineering	Total
Academic sector	62.3	61.0	44.3	55.7	32.6	49.6
Government sector	3.5	10.8	8.2	11.1	6.7	8.8
Industry/business sector	34.2	28.2	47.5	33.2	60.7	41.6

Source: our samples from SDR 1993 and SDR 1997.

The models for thesis-to-work transition

We model the probability of being in these different situations with a multinomial logit model. As a first step of analysis, we distinguish five situations (mutually exclusive) in which individuals are respectively in April 1993 and April 1997. Our polytomous dependent variable y_i takes these five outcomes:

- $y_i = 1$, if the individual is not in the labour force
- $y_i = 2$, if unemployed
- $y_i = 3$, if employed in the government sector (Federal State and local government)
- $y_i = 4$, if employed in the academic sector (two year college or other school system, four year college or medical institution, university)
- $y_i = 0$, if employed in the business or industry, as reference.

So, we estimate the following model:

$$\begin{cases} \Pr\left[y_i = 0 \middle| x_i\right] = \dfrac{1}{1+\sum_{j=1}^{3}\exp\left(x_i'\beta_j\right)} \\ \Pr\left[y_i = m \middle| x_i\right] = \dfrac{\exp\left(x_i'\beta_m\right)}{1+\sum_{j=1}^{3}\exp\left(x_i'\beta_j\right)} \quad \text{for } m = 1 \ldots 4 \end{cases}$$

where $\boldsymbol{\beta}_m = (\beta_{0m} ... \beta_{Km})'$ is the vector of parameters to estimate that includes K predictors (and the intercept) where the coefficient β_{km} is the effect of the independent variable x_k on outcome *m*. The vector $\boldsymbol{\beta}_m$ differs for each outcome of the dependant variable. We have to estimate 4(K+1) parameters.

Our independent variables x_i are constituted of three main categories of variables.

The first set of explanatory variables is constituted of individual characteristics:

- Gender, with male as reference.

- Age: we use a dummy variable as indicator of individuals who are less than 35 years old.

- Race/ethnicity: we are able to distinguish the White (as reference), Asian/Pacific Islander and under-represented minorities (Hispanic, Black or Native American).

- Citizenship status of individual: US and non-US citizen, with the former as reference.

The second group of variables is composed by characteristics of the doctorate earned by individuals:

- Field of doctorate: the disciplines are grouped in five major fields: mathematics and computer sciences, physical sciences, life sciences, social sciences and engineering. We use the physical sciences as reference. A more complete typology in 15 categories is also used in table 4 in the appendix. These dummy variables account for the specific influence of scientific disciplines and indirectly for the overproduction or occupational mismatch in a particular field.

- Financial support mechanisms for Ph.D.: in the SDR surveys, individuals are asked a question about the financial support they received for the doctorate.[32] Indeed, financial support mechanisms for Ph.D. have been studied mainly from the perspective on time-to-degree and completion rates of doctorate (Ehrenberg and Panangiotis 1995, Krueger 1998, Ferrer de Valero 2001). But financial support mechanisms are likely to influence the entry in the labour market of Ph.D.s by preparing them differently to the employment (National Academy of Science 1995). These variables can also account for the potential competencies of individuals. We test the influence of different combination of the financial support.

- Date of doctorate award: we create a dummy variable, with 1 for individuals who earned their doctorate on the 1990-94 period, and 0 otherwise. This variable indicate simply if there exists a global cohort effect.[33]

[32] The exact question asked is: "From which, if any, of these sources did you receive financial support for this degree?" and the different answers are: earnings from employer, financial assistance from employer, gifts, grants, loans, assistantship/work study, other.

[33] We have to think about it as an indicator of the labour market conditions for Ph.D.s. This dummy may also indicate a break or a transformation in the relative probabilities of being in the different situations.

- Geographical location of university awarding the doctorate in nine categories: Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific, New England. This latter region is used as reference.

The third set of variables is related to the expectations which individuals have regarding their doctorate, such as the planned career at the beginning of the doctorate.

Academic vs. non academic positions in the USA

Some major conclusions can be drawn from the estimates presented in the table 10.[34] We first briefly review the results concerning the probability of being out of the labour force and the probability of being unemployed, vs. the probability of being employed in the business or industry sector. However, when reading what follows, one has to remember that the out of the labour force status and the unemployment status are not clear indicators of the state of the labour market for this type of highly qualified manpower.[35] Then we will study the probability of being employed in the academia.

The probability of being out of the labour force and being unemployed (vs. being employed in the business or industry sector)[36] depends on gender, when controlling the effect of the other variables. The odds of being out of the labour force and being unemployed for females are respectively 5.1 times and 1.8 times as high as those for males.

The probability of being unemployed is higher for the member of the under-represented minorities (but with a relatively low significance level). But, neither this variable, nor the Asian variable, has an influence on the probability of being out of the labour force. The estimates presented in tables 1 and 2 in appendix show that the variable "under-represented minorities" increases the probability of being out of the labour force and the probability of being unemployed for the individuals who granted their doctorate between 1990 and 1994, but does not have an influence for those who earned their Ph.D. between 1985 and 1989. The inverse is true for the non-US citizens. This variable has neither effect on the probability of being out of the labour force nor effect on the probability of being unemployed for the whole sample. But, it increases the probability of being out of the labour force in 1993.

Ph.D.s with a doctorate in the mathematics and computer sciences and those with a doctorate in engineering, relative to the graduates who completed a doctorate in the physical sciences, have a lower probability of being out of the labour force and a lower probability of being unemployed.[37] The life sciences field seems to be specific. This variable increases the probability of being out of the labour force but does not have any effect on the probability of being unemployed. This effect is the same for the two cohorts. We can not attribute this effect

---

[34] We proceed to the estimation of numerous models before arriving to this one. By lack of space, we can not present the other estimations.

[35] Except for "exceptional" cases for some disciplines.

[36] In the remain of the text, we will not systematically rewrite "vs. to be employed in the business/industry" or "relatively to the probability of being employed in the business or industry sector". But one has to remember this sentence in his/her interpretation of the estimated coefficients.

[37] The effects among the two cohorts are not exactly the same but the sign of the coefficients remain even if the coefficients are not or few significant.

of the life sciences discipline to the specific composition by sex and race/ethnicity of this doctoral field because we control for these influences.

Financial support mechanisms have few or no effect on the probability of being out of the labour force or being unemployed (notably at the exception on the probability of being unemployment for individuals with grants as their major support sources, but with a low significant effect).

Now, we make some comment on the coefficients for the probability of being employed in the academic sector relative to the probability of being employed in business or industry.

Females are more likely to work in the academic sector relative to males, others things equal. Under-represented minorities have also a higher probability of being in the academia, compared to Whites. To the contrary, Asians are more likely to be employed in the business and industry. These results confirm those from the NSF (Kang 2001).

The probability of being employed in the academia (vs. employed in the business/industry) is clearly affected by the scientific field of the doctorate. Ph.D.s in engineering have clearly a lower probability of being employed in the academic sector (relative to Ph.D.s in physical sciences). All the other doctorate fields, except the chemistry and psychology field (Table 4 in the appendix), increase the probability of being employed in the academia.

Students who relied on a grant (fellowships, scholarships...) for their doctoral studies are more likely to have jobs in the academia. The inverse is true for Ph.D.s who had loans as their major financial support.

The location of university/college awarding doctorates have effects mainly on the probability of being employed in the government sector. But, the too broad geographical definition of this variable makes difficult the interpretation of these results; a new codification would be necessary.

Finally, the cohort effect indicates that the probability of being employed in the business/industry is decreased for the more recent cohort (1990-94).

Table 10. Situation in April 1993 and April 1997 of two cohorts of Ph.D. graduates awarded doctorate in 1985-89 and 1990-94

	Out of the labour force	Unemployed	Employed in government	Employed in academic sec.
Constant	-4.165***	-4.136***	-1.760***	-0.187**
	(0.302)	(0.462)	(0.150)	(0.083)
Female	1.632***	0.586***	-0.094	0.172***
	(0.141)	(0.191)	(0.077)	(0.045)
Race/ethnicity: Asian	-0.210	0.209	-0.185*	-0.376***
	(0.186)	(0.244)	(0.107)	(0.057)
Race/ethnicity: under-represented	0.305	0.453*	0.307***	0.320***
minorities	(0.187)	(0.270)	(0.106)	(0.067)
Non-US citizen	0.146	0.095	-0.858***	0.222***
	(0.199)	(0.260)	(0.136)	(0.060)
Less than 35	-0.082	-0.835***	-0.459***	-0.116**
	(0.140)	(0.218)	(0.080)	(0.046)
Ph.D. in mathematics and computer	-1.227**	-1.193*	-0.474**	0.676***
sciences	(0.528)	(0.609)	(0.224)	(0.091)
Ph.D. in life sciences	0.647***	-0.024	0.678***	0.802***
	(0.181)	(0.242)	(0.104)	(0.060)
Ph.D. in social sciences	0.018	-0.379	0.511***	0.517***
	(0.211)	(0.288)	(0.117)	(0.069)
Ph.D. in engineering	-0.590***	-0.771***	-0.361***	-0.505***
	(0.225)	(0.255)	(0.111)	(0.061)
Financial support for Ph.D.: grant	0.114	-0.450*	0.150*	0.228***
(fellowship, scholarship)	(0.149)	(0.241)	(0.079)	(0.047)
Financial support for Ph.D.: loan	-0.247	-0.038	-0.021	-0.211***
	(0.168)	(0.234)	(0.083)	(0.052)
Location of university awarding	0.385	0.919**	-0.068	-0.029
doctorate: Middle Atlantic	(0.273)	(0.458)	(0.149)	(0.080)
Location of university awarding	0.324	0.811*	-0.122	0.065
doctorate: East North Central	(0.271)	(0.457)	(0.146)	(0.078)
Location of university awarding	0.250	0.399	0.053	-0.030
doctorate: West North Central	(0.332)	(0.563)	(0.174)	(0.097)
Location of university awarding	0.568**	0.844*	0.607***	0.019
doctorate: South Atlantic	(0.274)	(0.471)	(0.140)	(0.083)
Location of university awarding	-0.404	1.025*	0.458**	-0.055
doctorate: East South Central	(0.513)	(0.588)	(0.199)	(0.127)
Location of university awarding	0.389	0.770	0.319**	0.110
doctorate: West South Central	(0.318)	(0.514)	(0.163)	(0.095)
Location of university awarding	0.242	1.211**	0.442**	0.191*
doctorate: Mountain	(0.369)	(0.508)	(0.175)	(0.105)
Location of university awarding	0.449*	0.711	0.114	0.089
doctorate: Pacific	(0.270)	(0.463)	(0.142)	(0.079)
Granted doctorate between 1990	0.303**	0.291	0.313***	0.144***
and 1994 (SDR 1997)	(0.145)	(0.200)	(0.079)	(0.047)
-2 log L	26135.77			
Number of observations	13065			

Source: SDR 1993 and SDR 1997. Notes: ML estimation of a multinomial logit model. Estimates with standard errors in parentheses. Samples merged form SDR 1993 and SDR 1997: Ph.D. graduates in 1985-89 from SDR 1993 and Ph.D. graduates in 1990-94 from SDR 1997. Dependent variable: situation of individuals respectively in April 1993 and April 1997, with “employed in business or industry” as reference. Significance levels of the coefficients: *** significant at the 1% level, ** significant à the 5% level, * significant at the 10% level.

Influence of individual expectations on the job held

The table 3 in the appendix adds expectation variables to the set of explanatory variables. At the beginning of the doctorate, most individuals expect to work in the academia; that is the case of 60% of the individuals in our 1997 sample.[38] But, about 25% of them have plans to work in the industry. In France, the proportion of Ph.D.s who would like to be employed in the academic sector seems relatively the same. In a survey that we made on 400 French Ph.D. graduates, more than 60% of them declare wanted to work in the academic sector after completing their theses. This variable may have an effect on the employment that individuals attain, by varying efforts in obtaining the desired career choice. But, as initial plans and employment are not perfectly matched for various reasons - and specifically changes in the initial career plans –, this variable is expected to have only a partial effect on the employment destination of individuals. So, the coefficients of the other variables in the model are expected to remain relatively the same after the introduction of this variable. But, one has to be careful in the interpretation of the model that results from the introduction of "psychological" variables (possible reinterpretation of the past by individuals...).

The estimated coefficients presented in the table 3 do not vary greatly from the initial model. Concerning the coefficients related to this variable, the probability of being in the academia is increased by the fact of having such a planned position at the beginning of the doctorate. The effect is opposite for the individuals who had business/industry as career choice. But, more surprisingly, the variable "most wanted to work in academia" increases the probability of being out of the labour force and the probability of being unemployed. No similar effect is observed for the individuals who planned a career in the industry.

Different measures of the subjective evaluation of the quality of job and study are available in the SDR survey.

Happiness with choice of field of study

An indirect measure that can be used to assess the quality of employment[39] available for Ph.D.s is the retrospective evaluation made by individuals on their Ph.D. doctorate and especially their Ph.D. fields. The question: "If you had the chance to do it again, knowing what you do now, how likely is it that you would choose the same field of study for your highest degree?" is particularly useful in this case.

Many factors influence the probability of being more or less happy with the choice of the doctorate field: the job satisfaction (characteristics of the job held such as earnings, part-time/full-time, sector of employment) and more general socio-economic characteristics. With ordered probit models we attempt to determine if there is an influence of the field of study on the probability of being more or less satisfied with the choice of study.

---

[38] The question "When you began your doctoral program, in what type of employment setting did you MOST want to work upon completing your doctorate?" is only available in the 1997 SDR. And this variable is not available for the whole sample we selected; the number of observations in the model presented in the table 3 is therefore lower than in the previous models.

[39] The job satisfaction of US Ph.D.s is analysed more precisely in another paper (Moguerou 2002).

We have three outcomes for the independent variable y_i which takes the values 0, 1 and 2 respectively for the categories “very likely”, “somewhat likely” and “very unlikely”. The outcome is discrete but of ordinal nature. So, we would like to estimate the following model:

$$y_i^* = -\beta' x_i + u_i$$

where y_i^* is the independent unobserved variable, x_i the vector of dependent variables, u_i the error terms and β the vector of parameters to estimate.

The observed variable y_i is related to the latent variable y_i^* such as:

$$\begin{aligned} y_i &= 0 \text{ if } y_i^* \leq 0 \\ y_i &= 1 \text{ if } 0 < y_i^* \leq \mu \\ y_i &= 2 \text{ if } \mu < y_i^* \end{aligned}$$

where μ is the unknown threshold parameter to estimate.

As we suppose u_i normally and identically distributed across observations with mean 0 and variance 1, we have:

$$\Pr(y_i = 0) = \Pr(y_i^* \leq 0) = \Pr(-\beta' x_i + u_i \leq 0) = \Pr(u_i \leq \beta' x_i) = \Phi(\beta' x_i)$$

$$\Pr(y_i = 1) = \Pr(0 < y_i^* \leq \mu) = \Pr(y_i^* \leq \mu) - \Pr(y_i^* \leq 0) = \Phi(\mu + \beta' x_i) - \Phi(\beta' x_i)$$

$$\Pr(y_i = 2) = 1 - \Phi(\mu + \beta' x_i)$$

where $\Phi(.)$ is the normal standard cdf.

We proceed to the ML estimation of the previous model. We included a sample selection term, with the estimation of a probit model in a first step, in the ordered probit but it has never been significant.

The estimates are provided in the table 11. As the wage increases, the probability of being happy with the choice of the field of doctorate increases. The sector of employment is another essential determinant. Those who work in the academic sector (compared to those working in the industry) are more likely to be happy with their choice of study. The field of doctorate has also a significant effect: computer and maths Ph.D.s are the most likely to be satisfied with their field of doctorate: the coefficients of all the other fields are negative in the major grouping of disciplines in the models 2 and 3 (we propose two different modes of grouping of Ph.D. disciplines: the first one in five categories for the models 2 and 3, the second one in fifteen categories for the model 4). Graduates in physical sciences and life sciences are the less likely to be satisfied. In the model 3, we include a dummy variable that takes the value 1 if the individual considers that his/her job activity is closely related to his/her field of doctorate, and 0 otherwise. Without surprise, this variable has a positive sign and is highly significant.

Table 11. Ordered probit model estimates: probability of "choosing the same field of doctorate"

	Model 1	Model 2	Model 3	Model 4
Constant	-0.504***	-0.270***	-0.481***	-0.516***
	(0.055)	(0.075)	(0.076)	(0.085)
Female	0.039	0.031	0.035	0.023
	(0.025)	(0.026)	(0.026)	(0.026)
Less than 35	0.035	0.047*	0.041	0.038
	(0.026)	(0.026)	(0.026)	(0.026)
Race/ethnicity: Asian	-0.180***	-0.185***	-0.160***	-0.185***
	(0.034)	(0.034)	(0.034)	(0.034)
Race/ethnicity: under-represented minorities	0.016	0.013	0.027	0.016
	(0.037)	(0.037)	(0.037)	(0.037)
Non US citizen	-0.144***	-0.151***	-0.180***	-0.152***
	(0.035)	(0.035)	(0.035)	(0.035)
Ph.D. in 1990-94	-0.076***	-0.067***	-0.068***	-0.067***
	(0.025)	(0.025)	(0.025)	(0.025)
Sector of employment: academic	0.213***	0.208***	0.121***	0.213***
	(0.030)	(0.030)	(0.030)	(0.030)
Sector of employment: government	0.031	0.041	-0.009	0.046
	(0.044)	(0.044)	(0.044)	(0.044)
Annual salary	9.57E-6***	9.82E-6***	8.58E-6***	8.47E-6***
	(6.92E-7)	(7.14E-7)	(7.16E-7)	(7.42E-7)
Part-time work	0.061	0.032	0.034	0.026
	(0.052)	(0.052)	(0.052)	(0.052)
Ph.D. in physical sciences		-0.339***	-0.329***	
		(0.056)	(0.056)	
Ph.D. in life sciences		-0.249***	-0.269***	
		(0.052)	(0.052)	
Ph.D. in social sciences		-0.117**	-0.169***	
		(0.055)	(0.055)	
Ph.D. in engineering		-0.132**	-0.134**	
		(0.054)	(0.054)	
Consider principal job as highly related to doctorate			0.401***	
			(0.027)	
Biological Sciences				-0.247***
				(0.053)
Other Life & Related Sciences				-0.275***
				(0.061)
Chemistry, except Biochemistry				-0.392***
				(0.065)
Physics and astronomy				-0.316***
				(0.068)
Other physical sciences				-0.270***
				(0.081)
Economics				-0.135
				(0.084)
Psychology				-0.076
				(0.061)
Sociology				-0.195**
				(0.080)
Other Social Sciences				-0.157**
				(0.077)
Chemical Engineering				-0.032
				(0.089)
Civil Engineering				-0.352***
				(0.098)
Electrical, Electronics and Communications Enginee				0.085
				(0.069)
Mechanical Engineering				-0.313***
				(0.083)
Other Engineering				-0.192***
				(0.062)
μ	0.999***	1.003***	1.019***	1.006***
	(0.015)	(0.015)	(0.016)	(0.015)
LR	19275	19213	18994	19170
Number of observations	9726	9726	9726	9726

Source: SDR 1997.

Notes: ML estimation of an ordered probit model. Reference for the field of doctorate awarded in the two modes of grouping: maths and computer sciences. Notation for the coefficients of the variable salary: 'E-6' means 10^{-6}.

Which type of academic jobs ?

We made a decomposition among academic jobs between tenured and non tenured jobs. Results are presented in the table 5 in the appendix. But this decomposition is only available in the 1995 SDR and seems not to be satisfactory. We have few information on this subject for instance in the SESTAT survey we have. Further investigations will be needed.

Main results: France

For France, we ran the same type of multinomial logit model as previously with a more detailed description of activities. The labour market situation of individuals in March 1999, about three years after they earned doctorate, is described with five categories. We made a complete new codification of the Céreq database to provide this typology of employment activities. This codification was done with the help of the complete name of the jobs, the employer... that are given "in clear" in the database. The different categories are the following:

- out of the labour force or unemployed
- being in a under-qualified job (blue collar, teacher in the secondary education…)
- being in a post-doc position abroad or in France (temporary research contract)
- being academics with a permanent position (tenured, civil servant) i.e. *maîtres de conférences* or *chercheurs CNRS*
- the reference outcome: being employed in the business or industry sector as scientist or engineer

The independent variables are of three types:

- individual characteristics: gender, age, socio-economic background… that are likely to influence the labour market prospects of Ph.D. graduates
- variables to account for the competencies and the experience of Ph.D. graduates. These variables can signal potential quality of the individual. These variables are also likely to express the networks or the relationships that individual gained during ones thesis. These variables are: the nature of the financial support for Ph.D. (grant from the Ministry of Higher Education, private firm funding, assistant teaching…), the structure where individual make ones thesis (laboratory of the Scientific National Research Centre…), the previous diploma before Ph.D. (graduates from a engineering school), the different activities during thesis (training period in a firm, teaching activities…), the duration of the thesis, the post-doctorate…
- the fields of the doctorate awarded in seven categories: mathematics and physics, chemistry, computer sciences, engineering, earth sciences, life sciences and social sciences, The reference is constituted by the mathematics and physics field.

Table 12. Situation in March 1999 of a cohort French Ph.D. graduates awarded doctorate in 1996

	Out of the labour force, unemployed	Under-qualified job	Post-doc	Academic position (tenured)
Constant	-5.340**	-7.108***	2.114	2.201
	(2.125)	(2.518)	(2.036)	(1.663)
Female	0.866***	0.648**	0.317	-0.033
	(0.232)	(0.273)	(0.225)	(0.193)
Financial support for Ph.D.: *Cifre*	-0.698**	-1.199***	-2.027***	-1.678***
(industrial funding, private firm)	(0.321)	(0.441)	(0.421)	(0.282)
Financial support for Ph.D.: *Allocation*	0.646**	-0.039	0.453*	0.014
(scholarship)	(0.265)	(0.317)	(0.248)	(0.215)
Financial support for Ph.D.: *Moniteur*	-0.098	0.870**	-0.005	0.729***
(assistant teaching)	(0.313)	(0.340)	(0.289)	(0.244)
Graduate from a engineering school	-0.645**	-0.773*	-0.186	-0.137
before Ph.D.	(0.300)	(0.400)	(0.266)	(0.215)
At least a training period in a private firm	-1.359***	-0.970**	-0.993***	-0.897***
during Ph.D.	(0.419)	(0.433)	(0.346)	(0.263)
Duration of thesis (in months)	0.019	0.019	0.021*	-0.007
	(0.012)	(0.013)	(0.012)	(0.010)
Age in 1996	0.119	0.188**	-0.125*	-0.054
	(0.077)	(0.091)	(0.075)	(0.060)
Ph.D. in chemistry	0.519	-0.337	-0.051	-0.678**
	(0.344)	(0.406)	(0.331)	(0.295)
Ph.D. in computer sciences	-2.191***	-1.565***	-0.915**	-0.566*
	(0.779)	(0.601)	(0.444)	(0.316)
Ph.D. in engineering, electronics	0.001	-0.794	-0.903**	-0.351
	(0.403)	(0.517)	(0.451)	(0.297)
Ph.D. in earth sciences	1.304**	-0.773	0.735	0.651
	(0.587)	(1.114)	(0.602)	(0.522)
Ph.D. in social sciences	0.137	-0.196	-0.268	0.955***
	(0.404)	(0.429)	(0.413)	(0.300)
Ph.D. in life sciences	0.610	0.330	1.381***	0.525*
	(0.375)	(0.403)	(0.332)	(0.306)
-2 log L		2803.11		
Number of observations		1060		

Source: Céreq 1999.
Notes: ML estimation of a multinomial logit model. Estimates with standard errors in parentheses. Reference for the dependent variable: employed as scientist or engineer in the private sector in March 1999 (three years after the completion of thesis). Reference category for the Ph.D. discipline: mathematics and physics. Significant levels: * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Ph.D.s who developed links with the private sector during their thesis have better labour market prospects. Three variables are important: *Cifre*, graduate from a engineering school and training period in a private firm. Roughly speaking[40], these variables decrease the probability of being unemployed or out of the labour force, being in a under-qualified position and being in a post-doc position (vs. being employed as researcher in the private sector). During their thesis, Ph.D.s who developed their relationships with the private sector have less

[40] We have not enough room here to comment more precisely the results.

difficulties in entering the labour market. Ph.D.s who were graduates from a engineering school (before their thesis) are likely to interest private firms because of their large competencies. They are not “pure scientists”. They could take high level management positions and not only scientific jobs. In that sense, they are likely to hold easily to a broader innovation community, to a larger internal labour market.

On the contrary, the labour market conditions are more difficult for Ph.D.s with strong relations with the public and academic research sectors. The *allocation* (scholarship)[41] has a positive effect on the probability of being unemployed or out of the labour force. This variable is not (still) sufficient to facilitate the entry in the labour market. Ph.D.s need to have other characteristics. They have to be *moniteur*[42] (assistant teaching) to access more easily to academic positions.

The fields of doctorate have effects on the probability of being out of the labour force or unemployed and on the probability of being academics. Note that the life sciences variable has a strong positive effect on the probability of being in a post-doctorate three years after the completion of thesis.

Conclusion

Similar patterns in the number of doctorate recipients have been found in France and in the USA for the last two decades. The number of doctorates awarded each year rose between the mid-1980s and the mid-1990s in the hard sciences fields in the two countries, with a stronger growth in France. The composition of the doctorates granted has also evolved with an increasing proportion of females receiving doctorates in the two countries and an increasing proportion of foreigners granting doctorates in the USA.

Our empirical investigation with micro dataset from Céreq and NSF shows that the different types of characteristics that influence the entry in the labour market are relatively the same among the cohorts of Ph.D. graduates in the two countries. Individual characteristics play a great role as well as characteristics related to the doctorate.

Even at this high level of diploma and in the two countries, females have a higher probability of being out of the labour force and a higher probability of being unemployed than males, other things equal.

Financial support received during the doctorate has an impact on the labour market conditions of Ph.D.s. For example, the Ph.D.s who benefited from a scholarship have a higher probability of being academics.

---

[41] The *allocataires* are chosen among the "best" students at the end of the master – students are ranked according to their academic performance in the year of the master. Those who are chosen to become *allocataires* will receive financial support (approx. scholarship) from the Ministry to make their doctorate. The *allocation* is paid for a three years period. Today, one third of the individuals who are making a Ph.D. are *allocataires*. The others have to find other financial sources.

[42] The *moniteurs* are chosen among the *allocataires*. They have teaching activities at university. They receive an additional source of financial support from the Ministry.

The field of the doctorate has an influence on the probability of being employed in the academic sector, and to a lesser extent, on being out of the labour force or being unemployed, when controlling the influence of the other variables. The probability of being unemployed or out of the labour force is much higher in France than in the USA. But this probability is similarly affected by the fields of the doctorate (the life sciences field increases it and the computer sciences decreases it). Therefore, an overproduction of Ph.D.s in some fields in France seems to be visible at the micro-economic level.

The probability of being employed in the academia is higher for Ph.D.s in the life sciences and Ph.D.s in social sciences in the two countries. But which type of academic jobs do these Ph.D.s have ? In the USA, we have for instance few information about that. An indirect assessment of the quality of the job held by individuals was made with the estimation of ordered probit models about the happiness of field of study. Ph.D.s in physical and life sciences are the less satisfied with their field of doctorate.

In France, it is clear that an important proportion of individuals is employed on post-doc positions or on non tenured positions – in France or abroad – more than three years after the award of their doctorate. Actually, there are great differences among fields. Life scientists have a far greater probability of holding such position. Further investigations on that subject will be necessary, especially to have a more precise picture of the post-doc positions.

Appendix

Table 1. Situation in April 1993 of Ph.D. graduates awarded doctorates on 1985-90

	Out of the labour force	Unemployed	Employed in government	Employed in the academic sector
Constant	-4.050***	-3.429***	-1.768***	-0.204***
	(0.295)	(0.296)	(0.137)	(0.074)
Female	1.835***	0.788***	-0.170	0.105*
	(0.215)	(0.269)	(0.109)	(0.064)
Race/ethnicity: Asian	-0.562*	0.148	-0.226	-0.398***
	(0.293)	(0.321)	(0.147)	(0.077)
Race/ethnicity: under-represented	0.076	0.247	0.402***	0.317***
minorities	(0.301)	(0.416)	(0.147)	(0.093)
Non-US citizen	0.634**	0.130	-1.068***	0.360***
	(0.285)	(0.350)	(0.209)	(0.081)
Less than 35	-0.381	-0.933**	-0.509***	-0.179***
	(0.257)	(0.402)	(0.133)	(0.067)
Ph.D. in mathematics and computer	---[a]	-0.696	-0.110	0.889***
sciences	(.)	(0.755)	(0.319)	(0.131)
Ph.D. in life sciences	0.684**	-0.241	0.910***	0.775***
	(0.276)	(0.343)	(0.148)	(0.082)
Ph.D. in social sciences	0.146	-0.362	0.852***	0.486***
	(0.319)	(0.401)	(0.166)	(0.096)
Ph.D. in engineering	-0.506	-0.632*	-0.221	-0.390***
	(0.334)	(0.330)	(0.155)	(0.080)
Financial support for Ph.D.: grant	0.314*	-0.307	0.103	0.268***
(fellowship, scholarship...)	(0.186)	(0.276)	(0.095)	(0.056)
Financial support for Ph.D.: loan	-0.308	-0.129	0.003	-0.130**
	(0.218)	(0.295)	(0.102)	(0.063)
-2 log L	14211.31			
Number of observations	7187			

Source: SDR 1993, our sample.

Notes: ML estimation of a multinomial logit model. Dependent variable: situation of individuals in April 1993, with "employed in business or industry" as reference. Reference category for the fields of doctorate: physical sciences. Significance levels of the coefficients: *** significant at the 1% level, ** significant à the 5% level, * significant at the 10% level.

(a) No individual was in the category in April 1993. So, to compute the ML estimation, this parameter is restricted and it is considered as infinite; the number of degrees of freedom is adjusted as such.

Table 2. Situation in April 1997 of Ph.D. graduates awarded doctorates on 1990-94

	Out of the labour force	Unemployed	Employed in government	Employed in the academic sector
Constant	-3.408***	-3.035***	-1.045***	0.055
	(0.280)	(0.356)	(0.148)	(0.091)
Female	1.466***	0.393	-0.035	0.243***
	(0.186)	(0.269)	(0.109)	(0.064)
Race/ethnicity: Asian	0.109	0.243	-0.245	-0.327***
	(0.241)	(0.367)	(0.156)	(0.087)
Race/ethnicity: under-represented	0.466*	0.656*	0.283*	0.318***
minorities	(0.240)	(0.358)	(0.150)	(0.096)
Non-US citizen	-0.314	0.058	-0.733***	0.044
	(0.274)	(0.379)	(0.184)	(0.091)
Less than 35	0.073	-0.799***	-0.475***	-0.080
	(0.177)	(0.262)	(0.103)	(0.063)
Ph.D. in mathematics and computer	-0.853	-1.742*	-0.840***	0.442***
sciences	(0.548)	(1.039)	(0.314)	(0.129)
Ph.D. in life sciences	0.627***	0.178	0.487***	0.795***
	(0.239)	(0.341)	(0.146)	(0.088)
Ph.D. in social sciences	-0.086	-0.384	0.153	0.491***
	(0.279)	(0.411)	(0.165)	(0.098)
Ph.D. in engineering	-0.652**	-0.918**	-0.463***	-0.721***
	(0.305)	(0.407)	(0.161)	(0.095)
Financial support for Ph.D.: grant	-0.293	-0.938*	0.135	0.182**
(fellowship, scholarship...)	(0.271)	(0.532)	(0.142)	(0.089)
Financial support for Ph.D.: loan	-0.048	0.180	-0.147	-0.284***
	(0.269)	(0.385)	(0.151)	(0.096)
-2 log L		11937.11		
Number of observations		5884		

Source: SDR 1997, our sample.

Notes: ML estimation of a multinomial logit model. Dependent variable: situation of individuals in April 1997, with “employed in business or industry” as reference. Reference category for the fields of doctorate: physical sciences. Significance levels of the coefficients: *** significant at the 1% level, ** significant à the 5% level, * significant at the 10% level.

Table 3. Situation in April 1997 of Ph.D. graduates awarded doctorates on 1990-94

	Out of the labour force	Unemployed	Employed in gov.	Employed in the academia
Constant	-4.133***	-3.904***	-0.230	-0.735***
	(0.436)	(0.608)	(0.196)	(0.150)
Female	1.544***	0.615**	-0.102	0.374***
	(0.208)	(0.289)	(0.125)	(0.078)
Race/ethnicity: Asian	0.027	0.390	-0.183	-0.213**
	(0.275)	(0.402)	(0.179)	(0.105)
Race/ethnicity: under-represented	0.368	0.824**	0.300*	0.292**
minorities	(0.275)	(0.371)	(0.173)	(0.117)
Non-US citizen	-0.198	-0.098	-0.719***	-0.107
	(0.293)	(0.418)	(0.206)	(0.109)
Less than 35	0.078	-0.837***	-0.253**	-0.086
	(0.204)	(0.287)	(0.121)	(0.078)
Ph.D. in mathematics and computer	-1.053*	-1.794*	-1.126***	0.137
sciences	(0.634)	(1.045)	(0.375)	(0.154)
Ph.D. in life sciences	0.704**	0.083	0.422**	0.619***
	(0.275)	(0.372)	(0.167)	(0.108)
Ph.D. in social sciences	-0.026	-0.297	-0.375*	0.321***
	(0.329)	(0.443)	(0.194)	(0.122)
Ph.D. in engineering	-0.469	-1.122**	-0.485***	-0.655***
	(0.343)	(0.480)	(0.186)	(0.117)
Financial support for Ph.D.: grant	-0.589	-0.908	0.188	0.123
(fellowship, scholarship...)	(0.393)	(0.627)	(0.190)	(0.127)
Financial support for Ph.D.: loan	-0.135	0.662	0.076	-0.093
	(0.398)	(0.445)	(0.202)	(0.141)
Most wanted to work in the academia	1.183***	1.316***	-0.631***	1.600***
at the beginning of the doctorate	(0.322)	(0.502)	(0.143)	(0.115)
Most wanted to work in	0.128	0.469	-1.685***	-0.420***
business/industry at the begin. doct.	(0.361)	(0.555)	(0.176)	(0.132)
-2 log L		8693.85		
Number of observations		4724		

Source: SDR 1997, our sample.

Notes: ML estimation of a multinomial logit model. Dependent variable: situation of individuals in April 1997, with "employed in business or industry" as reference. Reference category for the fields of doctorate: physical sciences. Significance levels of the coefficients: *** significant at the 1% level, ** significant à the 5% level, * significant at the 10% level.

Table 4. Situation in April 1993 and April 1997 of two cohorts of Ph.D. graduates awarded doctorate in 1985-89 and 1990-94

	Out of the labour force	Unempl.	Employed in gov.	Employed in the academia
Constant	-4.105***	-3.724***	-1.287***	0.119
	(0.402)	(0.510)	(0.183)	(0.108)
Female	1.666***	0.647***	-0.024	0.229***
	(0.142)	(0.193)	(0.079)	(0.046)
Race/ethnicity: Asian	-0.212	0.183	-0.171	-0.377***
	(0.186)	(0.245)	(0.108)	(0.058)
Race/ethnicity: under-represented minorities	0.302	0.427	0.350***	0.313***
	(0.188)	(0.271)	(0.107)	(0.068)
Non-US citizen	0.121	0.077	-0.929***	0.151**
	(0.200)	(0.260)	(0.137)	(0.062)
Less than 35	-0.057	-0.837***	-0.381***	-0.033
	(0.141)	(0.220)	(0.082)	(0.047)
Granted doctorate between 1990 and 1994 (SDR 1997)	0.279*	0.288	0.257***	0.076
	(0.146)	(0.202)	(0.080)	(0.047)
Financial support for Ph.D.: grant	0.095	-0.492**	0.143*	0.194***
	(0.149)	(0.242)	(0.080)	(0.048)
Financial support for Ph.D.: loan	-0.218	0.024	-0.002	-0.164***
	(0.168)	(0.234)	(0.084)	(0.053)
Computer and Mathematical Sciences	-1.298**	-1.645**	-0.973***	0.337***
	(0.594)	(0.650)	(0.247)	(0.114)
Biological Sciences	0.526	-0.496	0.055	0.421***
	(0.333)	(0.346)	(0.154)	(0.094)
Other Life & Related Sciences	0.686*	-0.495	0.418**	0.504***
	(0.363)	(0.427)	(0.171)	(0.110)
Chemistry, except Biochemistry	-0.254	-0.709*	-1.412***	-0.872***
	(0.372)	(0.384)	(0.212)	(0.109)
Other Physical & Related Sciences	0.402	-0.459	0.476**	0.470***
	(0.472)	(0.590)	(0.220)	(0.147)
Economics	0.556	-0.310	0.738***	0.543***
	(0.462)	(0.592)	(0.228)	(0.156)
Psychology	-0.365	-1.456***	-0.275	-0.407***
	(0.367)	(0.449)	(0.171)	(0.107)
Sociology & Anthropology	0.229	0.368	0.360	1.218***
	(0.539)	(0.533)	(0.281)	(0.175)
Other Social Sciences	0.579	-0.218	0.266	1.035***
	(0.468)	(0.599)	(0.262)	(0.161)
Chemical Engineering	-0.334	-0.596	-1.810***	-1.616***
	(0.439)	(0.421)	(0.272)	(0.137)
Civil Engineering	-0.507	-1.421*	-0.074	-0.456***
	(0.665)	(0.770)	(0.232)	(0.150)
Electrical, Electronics and Communications Enginee	-0.934**	-1.332***	-1.361***	-0.905***
	(0.459)	(0.458)	(0.218)	(0.110)
Mechanical Engineering	-0.983	-1.517**	-0.685***	-0.644***
	(0.661)	(0.650)	(0.229)	(0.129)
Other Engineering	-0.629	-1.429***	-0.540***	-0.653***
	(0.413)	(0.443)	(0.171)	(0.103)
Location of university awarding doctorate: Middle Atlantic	0.393	0.923**	-0.058	0.004
	(0.274)	(0.458)	(0.150)	(0.082)
Location of university awarding doctorate: East North Central	0.342	0.841*	-0.089	0.113
	(0.272)	(0.458)	(0.147)	(0.079)
Location of university awarding doctorate: West North Central	0.278	0.452	0.101	0.052
	(0.333)	(0.563)	(0.176)	(0.099)
Location of university awarding doctorate: South Atlantic	0.577**	0.889*	0.620***	0.057
	(0.274)	(0.472)	(0.141)	(0.085)
Location of university awarding doctorate: East South Central	-0.358	1.112*	0.492**	0.063
	(0.514)	(0.589)	(0.201)	(0.129)
Location of university awarding doctorate: West South Central	0.404	0.805	0.333**	0.175*
	(0.319)	(0.515)	(0.164)	(0.097)
Location of university awarding doctorate: Mountain	0.255	1.259**	0.425**	0.219**
	(0.370)	(0.509)	(0.177)	(0.107)
Location of university awarding doctorate: Pacific	0.454*	0.744	0.108	0.105
	(0.270)	(0.463)	(0.143)	(0.080)
-2 log L	25611.07			
Number of observations	13065			

Source: SDR 1993 and SDR 1997.

Notes: ML estimation of a multinomial logit model. Estimates with standard errors in parentheses. Samples merged form SDR 1993 and SDR 1997: Ph.D. graduates in 1985-89 from SDR 1993 and Ph.D. graduates in 1990-94 from SDR 1997. Dependent variable: situation of individuals respectively in April 1993 and April 1997, with "employed in business or industry" as reference. Reference category for the fields of doctorate: physics and astronomy. Significance levels of the coefficients: ***significant at the 1% level, **significant at the 5% level, *significant at 10% level.

Table 5. Situation in April 1995 for Ph.D. graduates who awarded doctorates in 1985-94 and in 1990-94

	Out of the lqbour force	Unemployed	Employed in industry	Academic non tenured	Academic tenured
Constant	-2.224***	-1.714***	1.608***	0.607***	1.047***
	(0.235)	(0.240)	(0.109)	(0.118)	(0.114)
Female	1.753***	0.505***	0.047	0.186**	0.204**
	(0.162)	(0.180)	(0.082)	(0.084)	(0.084)
Ph.D. in mathematics and	-0.235	0.228	0.406*	1.398***	0.401*
computer sciences	(0.489)	(0.430)	(0.223)	(0.226)	(0.229)
Ph.D. in life sciences	0.100	-0.403*	-0.717***	0.161	-0.111
	(0.212)	(0.235)	(0.111)	(0.119)	(0.114)
Ph.D. in social sciences	-0.351	-1.179***	-0.673***	0.066	-0.684***
	(0.241)	(0.303)	(0.124)	(0.131)	(0.130)
Ph.D. in engineering	-0.408	-0.080	0.453***	0.044	-0.332***
	(0.281)	(0.257)	(0.119)	(0.132)	(0.127)
Financial support for Ph.D.:	-0.096	-0.073	-0.065	0.284***	0.042
grant	(0.167)	(0.200)	(0.085)	(0.087)	(0.088)
Financial support for Ph.D.:	-0.202	-0.015	0.073	-0.074	-0.226**
loan	(0.184)	(0.215)	(0.090)	(0.093)	(0.095)
Race/ethnicity: Asian	0.276	0.168	0.483***	0.017	0.392***
	(0.186)	(0.221)	(0.099)	(0.107)	(0.103)
Race/ethnicity: under-	-0.180	0.407*	-0.239**	0.188	0.018
represented minorities	(0.232)	(0.235)	(0.116)	(0.115)	(0.118)
Cohort 1990-94	-0.259	0.292	-0.265***	-0.018	-0.057
	(0.161)	(0.185)	(0.081)	(0.084)	(0.084)
Less than 35	0.786***	-0.084	0.574***	0.419***	0.581***
	(0.158)	(0.193)	(0.085)	(0.089)	(0.088)
-2 log L			31955.57		
Number of observations			11942		

Source: SDR 1995.

Notes: ML estimation of a multinomial logit model. Dependent variable: situation of individuals in April 1995, with “employed in government” as reference. Reference category for the fields of doctorate: physical sciences. Significance levels of the coefficients: *** significant at the 1% level, ** significant à the 5% level, * significant at the 10% level.

Table 6. Number of doctorates awarded in the USA (1970-2000)

	1970	1975	1980	1985	1990	1995	2000	00/85	95/85	00/95
All Fields	**29,498**	**32,952**	**31,020**	**31,297**	**36,067**	**41,742**	**41,368**	**32.2**	**33.4**	**-0.9**
Physical Sciences	**5,628**	**4,857**	**4,111**	**4,531**	**5,859**	**6,808**	**6,077**	**34.1**	**50.3**	**-10.7**
Physics and Astronomy	1,655	1,300	983	1,080	1,393	1,652	1,392	28.9	52.9	-15.7
Chemistry	2,238	1,776	1,538	1,836	2,100	2,162	1,990	8.4	17.7	-7.9
Earth,Atmos., and Marine sciences	510	634	628	617	769	807	786	27.4	30.7	-2.6
Mathematics	1,225	1,147	744	688	892	1,190	1,048	52.3	72.9	-11.9
Computer Sciences	-	-	218	310	705	997	861	177.7	221.6	-13.6
Engineering	**3,434**	**3,002**	**2,479**	**3,166**	**4,894**	**6,008**	**5,330**	**68.4**	**89.7**	**-11.2**
Life Sciences	**4,693**	**5,026**	**5,461**	**5,780**	**6,605**	**7,917**	**8,529**	**47.6**	**37.0**	**7.7**
Biological Sciences	3,361	3,497	3,803	3,793	4,328	5,375	5,855	54.4	41.7	8.9
Health Sciences	414	462	586	729	956	1,330	1,589	118.0	82.4	19.4
Agricultural Sciences	918	1,067	1,072	1,258	1,321	1,212	1,085	-13.8	-3.6	-10.4
Social Sciences	**4,566**	**6,066**	**5,855**	**5,765**	**6,093**	**6,635**	**7,115**	**23.4**	**15.1**	**7.2**
Psychology	1,890	2,751	3,098	3,118	3,281	3,429	3,623	16.2	9.9	5.6
Anthropology	217	386	370	353	324	375	446	26.4	6.2	18.9
Economics	853	895	767	811	862	979	948	16.9	20.7	-3.1
Political Sciiences	636	862	585	484	559	673	747	54.3	39.0	11.0
Sociology	505	680	600	461	428	540	615	33.4	17.1	13.9
Other Social Sciences	465	492	435	538	639	639	736	36.8	18.7	15.2
Humanities	**4,278**	**5,046**	**3,872**	**3,429**	**3,822**	**5,061**	**5,634**	**64.3**	**47.6**	**11.3**
History	1,091	1,183	745	543	612	889	1,060	95.2	63.7	19.2
Americ. and English Lang and Litt.	1,098	1,290	952	729	796	1,079	1,070	46.8	48.0	-0.8
Foreign Lang and Lit	647	826	535	435	512	639	641	47.4	46.9	0.3
Other Humanities	1,442	1,747	1,640	1,722	1,902	2,454	2,863	66.3	42.5	16.6
Education	**5,857**	**7,360**	**7,586**	**6,733**	**6,510**	**6,649**	**6,420**	**-4.6**	**-1.2**	**-3.4**
Teacher Education	563	570	639	463	419	390	260	-43.8	-15.8	-33.3
Teaching fields	1,384	1,417	1,471	1,118	922	924	828	-25.9	-17.4	-10.3
Other Education	3,910	5,373	5,476	5,152	5,169	5,335	5,332	3.5	3.5	-0.0
Professional, Other Fields	**1,042**	**1,595**	**1,656**	**1,893**	**2,284**	**2,664**	**2,263**	**19.6**	**40.7**	**-15.1**
Business and Management	584	787	640	790	1,036	1,327	1,071	35.6	67.9	-19.2
Communications	27	264	270	266	323	380	389	46.2	42.8	2.3
Other Professional	277	524	724	812	858	931	797	-1.8	14.6	-14.3
Other Fields	154	20	22	25	67	26	1	-96.0	4	-96.1

Source: Survey of Earned Doctorates (2001). Three last columns: growth rates between the respective years.

References

American Astronomical Society (1997), *An Examination of Graduate Education in Astronomy* (http://www.aas.org/publications/baas/v29n5/edrpt.html)

Association of American Universities. (1998). *Committee on Postdoctoral Education: Report and recommendations*, Washington, DC: Association of American Universities

Auriol L. and Sexton J. (2001), "Human Resources in science and technology: measurement issues and international mobility", *Paper presented in the framework of the 5th Ibero American and Inter American Workshop on Science and Technology Indicators*, Montevideo, Uruguay, 16 October

Balter M. and Normile D. (1999), "Europeans who do postdocs abroad face reentry problems", *Science* 285, No.5433, Sep. 3, pp.1524-26

Beltramo J.P., Bourdon J. and Paul J.J. (1996), "An Attempt to Forecast the Labor Market for Scientists in France", *Higher Education and Work*, Brennan J., Kogan M. and Teichler U. (eds.)

Blanchflower D. G. and Freeman R. B. (eds. 2000), *Youth Employment and Joblessness in Advanced Countries*, The University of Chicago Press, 492 p.

Borghans L. and De Grip A. (eds. 2000), *The Overeducated Worker ? The Economics of Skill Utilization*, Edward Elgar, 271 p.

Borthwick S. and Murphy T. (1998), *Supply and Demand for Scientists and Engineers*, Department of Employment, Education, Training and Youth Affairs, Analysis and Evaluation Division, Australia, 30 p.

Braddock D. J. (1992), "Scientific and Technical Employment, 1990-2005", *Monthly Labor Review*, February 115(2), pp.28-41

Cahuc P. and Postel-Vinay F. (2000), "On Some Undesirable Consequences of Education and Growth", *Journal of Institutional and Theoretical Economics* 156(3), September 2000

Card D. and Lemieux T. (1997), "Adapting to Circumstances: The Evolution of Work, School and Living Arrangements Among North American Youth", *Working Paper* 386, Industrial Relations Section, princeton University

Card D. and Lemieux T. (2000), "Dropout and Enrollment Trends in the Post-war Period: What Went Wrong in the 1970s ?", *NBER Working Paper* 7658, April

Carmichael L. H. (1988), "Incentives in Academia: Why is There Tenure", *Journal of Political Economy* 96(3), p.453-472

Carnoy M. (1998), "The Globalization of innovation, nationalist competition, and the internationalization of scientific training", *CHET Working Paper* (Centre for Higher Education Transofmration), April, 33 p.

Christian M. (2000), "Investigating Cobweb Labor Supply Models: A Vector Autoregression Approach", *Working Paper*, University of Michigan

Davis G. (1997), "Mathematics and the Market", *Notices of the AMS*, November

Dolton P. and Silles M. (2001), "Over-Education in the Graduate Labour Market: Some Evidence from Alumni Data", *Working Paper Centre for the Economics of Education*, LSE, June

Drost A. (2000), “The Dynamics of Occupational Choice. Theory and Evidence”, *Working Paper, University of Cologne*, Department of Economics, 21 p.

Ehrenberg R. G. and Panagiotis M. G. (1995), “Do Doctoral Students Financial Support Patterns Affect Their Time-to-Degree and Completion Probabilities”, *Journal of Human Resources* 30(3), pp.581-609

Euroscience (1998), *The Future of Young Scientists in Europe*, draft report of the ad hoc Euroscience work group, October 20

Felderer B. and Drost A. (2000), “Cyclical Occupational Choice in a Model with Rational Wage Expectations and Perfect Occupational Mobility”, *Economics Series* 81, Institute for Advanced Studies, Vienna, March

Ferrer de Valero Y. (2001), “Departmental Factors Affecting Time-to-Degree and Completion Rates of Doctoral Students at One Land-Grant Research Institution”, *Journal of Higher Ecucation* 72(3), May/June, 341-367

Finn M., Pennington L. A. and Anderson K. H. (1995), *Foreign Nationals Who Receive Science or Engineering Ph.D.s from U.S. Universities: Stay Rates and Characteristics of Stayers*, Oak Ridge Institute for Science and Education

Finn M. (1999), “Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1997”, *Institute for Science and Education*, Oak Ridge, TN: Oak Ridge

Freeman R. (1975), “Legal 'Cobwebs': A Recursive Model of the Market for New Lawyers” *Review of Economics and Statistics* 57:2 (May 1975)

Freeman R. (1975a), “Supply and Salary Adjustments to the Changing Science Manpower Market: Physics 1948-73”, *American Economic Review* 65(1), pp.27-39

Freeman R. (1989), “Supply and salary adjustments to the changing market for physicists”, *in Labor Markets in Action*, Harvard University Press

Freeman R. B. and Leonard J. (1978), "Autoregressive Degree Patterns: Evidence of Endogenous Cycles in the Market?”, *Proceedings of the Industrial Relations Research Association*, Winter, pp. 10-19

Golde C. M. and Dore T. M. (2001), *At Cross Purposes: What the experiences of doctoral students reveal about doctoral education*, A report prepared for The Pew Charitable Trusts, Philadelphia, PA

Gustman A. and Steinmeier T. (1981), “The Impact of Wages and Unemployment on Youth Enrollment and Labor Supply”, *Review of Economics and Statistics* 63, pp. 553-560.

Holden C. (1999), “Eight attributes of highly succesful postdocs”, *Science* 285, No. 5433, Sep. 3, pp.1527-29

Johnson J. M. (2000), *Graduate Education Reform in Europe, Asia and the Americas and International Mobility of Scientists and Engineers*, Proceedings of an NSF Workshop, April

Johnson J. M. (2000), *International Mobility of Doctoral Recipients from U.S. Universities*, Council of Graduate Schools, 40th Anniversay Meeting, December 5-9

Kang K. H. (2001), “Academic Employment of Recent Science and Engineering Doctorate Holders”, *Issue Brief* NSF 01-332, Division of Science Resources Studies, National Science Foundation

Krueger A. B. (1998), “Forecasting Successful Economics Graduate Students”, *Working Paper* 403, Industrial Relatons Section, Princeton University

Light A. (1995), "Hazard Model Estimates of the Decision to Re-enroll in School", *Labour Economics* 2, pp. 381-406.

Magner D. K. (1998), "'Postdocs', seeing little way into the academic job market, seek better terms in the lab", *The Chronicle of Higher Education* 44(48), Aug. 7, pp.10-12

Malcom S., Van Horne V., Gaddy C., and George Y. (1998), *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans*, report to the American Association for the Advancement of Science

Mangematin V. (2000), "Ph.D. Job Market: Professional Trajectories and Incentives during the Ph.D.", *Research Policy* 29(6), pp.741-756

Marey P., de Grip A. and Cörvers F. (2001), "Forecasting the Labour Markets for Research Scientists and Engineers in the European Union", *Working Paper* ROA-W-2001/3E, published in annex 2 of Pearson R. *et al*. (2001)

Massy W. and Goldman C. (1995), "The Production and Utilization of Science and Engineering Doctorates in the United States", *Stanford Institute for Higher Education Working Paper*

Matloff N. (1998), "Debunking the Myth of a Desperate Software Labor Shortage", Department of Computer Science, University of California at Davis

MLA (1997), *Report from MLA* (Modern Language Association) Comitee on Professional Employment, December

Moguerou P. (2002), "Job satisfaction among US Ph.D. graduates: the effects of gender and employment sector", IREDU Working Paper

Morgan M., Burrelli J. and Rapoport A. (2000), *Modes of Financial Support in Graduate Education of Science and Engineering Doctorate Recipients*, Topical Report, Division of Science Resources Studies, NSF, May

Muysken J. and Bas ter Weel (1999), "Overeducation, Job Competition and Unemployment", *paper presented to the EALE Annual Conference*, Ragensburg, 23-26 September

National Academy of Science (1995), *Reshaping the Graduate Education of Scientists and Engineers*. The Committee on Science, Engineering and Public Policy. National Academy Press, Washington, DC 1995

National Research Council (1998), *Trends in the Early Careers of Life Scientists*. Committee on Dimensions, Causes, and Implications of Recent Trends in the Careers of Life Scientists. Board on Biology, Commission on Life Sciences, Office of Scientific and Engineering Personnel, National Academy Press (http://books.nap.edu/html/trends)

National Science Board (2000), *Science and Engineering Indicators*, National Science Foundation

Maresi N. et Cerny J. (1999), "Postdoctoral Patterns, Career Advancement, and Problems", *Science* 285, No.5433, Sep. 3, pp.1533-35

Normile D. (1999), "New Career Paths for Young Scientists », *Science*, Apr. 9, 284, No. 5412, pp.233-234

North D. S. (1995), *Soothing The Establishment. The Impact of Foreign-Born Scientists and Engineers on America*, University Press of America, Lanham

OECD (2000), *Knowledge Management in the Learning Economy*, Centre for Educational Research and Innovation, 257 p.

Pearson R., N. Jagger, H. Connor, S. Perryman, P. Marey, A. de Grip, F. Cörvers (2001), *Assessing the Supply and Demand for Scientists and Technologists in Europe*, IES Report 377, Institute for Employment Studies, 215 p.

Pollack-Johnson B., Dean B. V., Reisman A. and Mihenzi A. R. (1990), "Predicting Doctorate Production in the USA: some lessons for long-range forecasters", *International Journal of Forecasting* 6, pp. 39-52

Regets Mark C. (1998), "Has the use of postdocs changed?", *Issue Brief* 99-310, Division of Science Resources Studies, National Science Foundation

Ryan P. (2001), "The School-to-Work Transition: A Cross-National Perspective", *Journal of Economic Literature* 39(1), March, pp.34-92

Schneider A. (2000), "Seeking an end of 'postdoc hell'", *The Chronicle of Higher Education* 47(3), Sep 22

Siow A. (1995), "The Organization of the Market for Professors", *Working Paper* UT-ECIPA-SIOW 95-01, Department of Economics, University of Toronto, May, 58 p.

Stephan P. E. (1999), "Using Human Resource Data to Illuminate Innovation and Research Utilization", *Issues paper prepared for the workshop on Using Human Resources to Assess Research Utilization and Innovation,* Board on Science, Technology and Economic Policy, National Research Council

Stephan P. E. and Levin S. (1997), "The Critical Importance of careers in Collaborative Scientific Research", *Revue d'Economie Industrielle* 79(1), p.45-61

Stock W. A. and Siegfried J. J. (2001), "So You Want to Earn a Ph.D. in Economics: How Much Do You Think You'll Make ?", *Economic Inquiry* 39(2), April, pp.320-335

Tsapogas J. (2001), "Retention of the best minority graduates in science and engineering", *Making Strides Newsletter* 3(1), January

Ward M. (1999), "Your Everyday, Average Academic", *IZA Discussion Paper* 63, October

Weinstein E. (2000), "How and Why Government, Universities, and Industry Create Domestic Labor Shortages of Scientists and High-Tech Workers", Working Paper

Zarkin G. A. (1983), "Cobweb vs. Rational Expectations Model: Lesson from the Market of Public School Teachers", *Economics Letters* 13, pp.83-95

Zarkin G. A. (1985), "Occupational Choice: An Application to the Market for Public School Teachers", *Quarterly Journal of Economics* 100, pp.409-46

Zucker L., Darby M. and Torero M. (1997), "Labor Mobility from Academie to Commerce", *NBER Working Paper* 6050, May