High Unemployment and Non Tenured Jobs in the Scientific Labour Market: Institutions and Occupational Mismatch

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Abstract

In this paper we analyse the recent labour market prospects for scientific PhD graduates. At the end of the 1990s in France, PhD graduates have low labour market prospects in some scientific fields. Firstly, we test indirectly if this situation is due to an overproduction of PhDs in some scientific disciplines. Secondly, we show that this effect of scientific field is not sufficient to explain the difficulties PhD graduates encounter when they enter the labour market. Institutional factors, such as the specific position of PhDs in the innovation and technological systems, explain a part of these difficulties. The recent transformations in the innovation systems could increase these difficulties for PhD graduates who do not have specific characteristics (strong links with the innovation community, broad competencies…).

Introduction

This paper attempts to develop a comprehensive framework explaining the recent transformations in the French scientific labour market. Our hypothesis is that the persistence of high unemployment rates among PhD graduates in the 1990s in France can be explained by the transformations in the scientific internal labour market. Career perspectives for scientific graduates have been more difficult since the beginning of the 1990s. This situations is really different from the ones in the UK and the USA. In France, non tenured-jobs and part-time jobs rose sharply in public or private research-intensive institutions in that period of time.

Our study is not in the tradition of the "equilibrium perspective" of the scientific labour market, even if some facts on the French scientific labour market of the 1990s can be explained by the demand and supply of PhDs. Our hypothesis is that in some scientific fields, there was an overproduction of PhD graduates in the 1990s. Consequently, PhDs in such disciplines have low labour market prospects at the end of the 1990s. We could speak of a occupational mismatch in such scientific fields. We test indirectly this hypothesis with two survey on the entry of higher education graduates carried out in 1997 and 1999 (section I).

In the section II, we attempt to explain endogenously the difficulties of PhD graduates in the labour market. In our sense, the explanation related to the flows of PhD graduates in the tradition of the equilibrium perspective is not sufficient. The specific position of PhDs in the French research, innovation and technological systems must be taken into account (the institutional part). The evolution of the French innovation system in the 1990s increase the difficulties in the labour market for some PhD graduates (development of intermediate structures at the interface between public and private research sectors…). Our hypothesis is that PhDs who do not have specific characteristics (broader competencies than their only scientific ones) have low labour market prospects. Broader competencies are required to enter in good conditions in the new innovation community.

Section I. The equilibrium perspective of the scientific labour market: an occupational mismatch ?

The dynamics of demand and supply of PhDs in the 1990s in France lead some commentators to be worried about a possible overproduction of PhD graduates during this period. That was especially the conclusion of a report to the French Higher Education and Research Ministry, at the beginning of the 1990s (Beltramo *et al.* 1996). This kind of studies is keeping in a long tradition of empirical studies on the needs of scientists and engineers in different countries. Some papers concluded that there are "too few" scientists, "too many" or sometimes "too many now, but too few in the near future" (Diamond 1996, p.18). Projections of scientific manpower are often done at the national level and at a ten-year horizon (Pollack-Johnson *et al.* 1990). At the theoretical level, some studies applied a Jovanovic job matching model to explain the evolution of demand and supply of scientists. In a microeconomic perspective, the most quoted article of the interactions of supply and demand in the labour market for scientists is the "cobweb" model of Richard Freeman (1975).[1]

[1] See also Freeman 1971, 1980 and 1989.

The development of higher education in France led to an increase in the number of PhD awarded in the 1990s.

In the meantime, in the context of a slow economic growth, the demand for scientists was relatively slow.

Thus, in a equilibrium perspective, we can conclude that labour market prospects for PhD graduates may be more difficult. We suggest an assessment of the situation of scientific PhD graduates in the labour market. We test indirectly if there was an overproduction of scientific PhD graduates in some fields in the 1990s in France. Our hypothesis is that there was an occupational mismatch in some scientific fields. We assess this occupational mismatch by the different labour market prospects for PhD graduates, when controlling for the influence of other variables.

1.1. The increase in the supply of doctoral programmes

The development of the French higher education system contributes to the increase in the number of PhD awarded in France. But the specific public policies in favour of research have had an effect on the increase in the number of theses granted in the 1990s in France. (see the appendix for a short description of the organisation of doctoral studies in France).

1.1.1. The growth in the number of students: the mutual influence of demand and supply

The increase in the higher education graduates can be explained by supply or demand factors. The famous slogan "80 % of an age group reaching the *baccalauréat*", launched in 1985, encouraged students to carry on with their studies. Other public measures fostered incentives for students to delay their entry into the labour market. But the personal choices of pursuing studies had also been an important factor in the development of higher education.

The principal aim of the French education policy of the 1980's was to develop the level of educational attainment of the labour force. France seems to have a fewer proportion of its population in the secondary and higher education systems than most OECD countries. The active policy led in the secondary education largely explained the sharp increase in the number of *baccalauréat* holders. Many policy measures – a very ambitious target for access to the last year of secondary education, the creation of technological *baccalauréat*… – stimulated demand for secondary education and, therefore, for higher education. The number of applicants to the higher education system follows the number of *baccalauréat* holders. The French system of higher education is dual. The tracks of the universities open to all holders of *baccalauréat*. The "schools" constitute a more closed system where the access is limited and competitive. There also exists short tracks (two years following the *baccalauréat*) that are more vocational than the long tracks of the universities which have a more broad curriculum. The proportion of an age group reaching *baccalauréat* level progressed of 34 % in 1980 to more than 70 % today. And the proportion of *baccalauréat* holders of 26 % to 60 % in the same period.

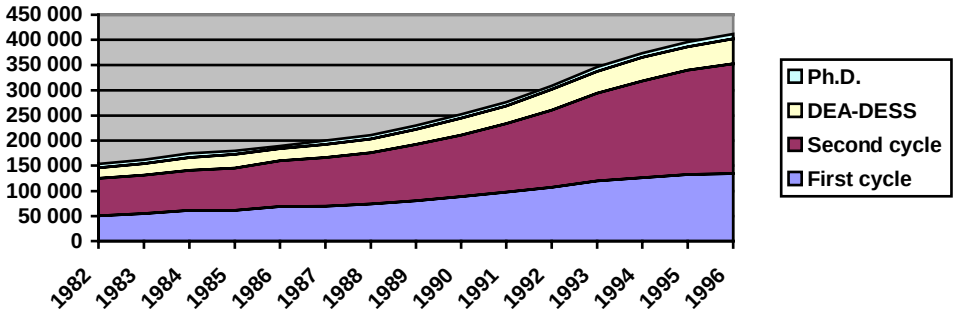
A rapid growth in the number of students can be seen between the mid-1980's and the beginning of the 1990's. The number of students in the higher education was of 1.2 million in 1980 and of 2.2 millions in 1996. This increase concerned not only the open system but also the closed system of the schools and the short tracks. At the level of higher education, many policies also encouraged students to continue their studies: new university departments and

university institutes of technology were developed, and more generally we assist at a development of vocational tracks within the universities…

But these supply factors are not sufficient to explain the increase of the number of students. Demand for secondary and higher education increased. Since the mid 1980's, almost all general *baccalauréat* holders have tended to carry on with their studies in higher education system. Demography is not responsible for the growth of the number of students. The birth rate have tended to fall since the mid 1960's. The schooling rates at the different levels of education have raised sharply for 15 years. The desire, which was encouraged by the active policies, to go on studying has been greater since the mid 1980's.

This triggered an explosion in the outward flows of higher education graduates.[2] Between 1982 and 1996, the annual growth rates of the university graduates were respectively of 7.2%, 8% and 5.4% for the first, second and third university cycles (cf. figure 1).

Figure 1. Number of university graduates by cycles (1982-1996)



Source: DPD-MENRT ("Direction de la programmation et du développement", "Ministère de l'éducation nationale, de la recherche et de la technologie" = ministry of education and research).

The different disciplines benefited differently from this increase in the number of graduates. The rise had been greater in science disciplines than in the arts, humanities and social sciences.

Table 1. University graduates by disciplines

	Second cycle		DEA-DESS	
	Number 1996	1996/82	Number 1996	1996/82
Arts, humanities and social sciences	88253	199	13297	93
Business and economics	36860	247	10686	156
Law and political sciences	36145	166	9244	160
Sciences disciplines	57019	241	1614	145

Source: DPD-MENRT.

[2] The number of graduates follow approximately the number of students, if on considers that the passing rates are relatively stable. The outflows of the higher education which represented one fifth of the whole outflow of the education system in 1980 represent actually a third.

The number of PhD awarded in France also rose sharply during this same period: 11,000 PhD were awarded in France in 1997 for only 6,000 PhD at the beginning of the 1980's (for all disciplines at the exception of medicine).

1.1.2. The increase in the number of theses in the 1990's

The increase in the number of PhDs awarded in France in the 1990s is a consequence of three main facts. Firstly, the development of higher education increased the number of graduates available for making a thesis. Secondly, public policies in favour of the development of public research had also played a role in this steeply rise. Thirdly, in a context of a high unemployment of young professionals, the incentives to continue ones study is important.

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.[3] 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. 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.[4] Public responses to this anticipated shortage in the number of researchers were conducted in many ways: funding of thesis have been developed since the mid-1980's[5], education and research policies attempted to develop scientific departments in universities, 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[6] PhDs 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 PhD 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 incentives for students to make a thesis are really complex (Mangematin 2000). The investment in human capital is one of the most popular explanation. But, in the case of PhD, this explanation must be completed by other considerations. The institutional

[3] A main concern for economists is the determinants of economic growth. Education and research are often considered as a major contribution to economic growth. Recent developments in the field of endogenous growth contributed to a certain renewal of those approaches after the seminal papers of Romer (1986) and Lucas (1988). The introduction in the agregate production function of a new factor of production, often called "knowledge", which is not concerned with the law of decreasing returns to scale is the major innovation of this approach. Knowledge spillovers are therefore a major source of long-term economic growth. Some models (Lucas, 1988; King, Plosser, Rebelo, 1988; Becker, Murphy, Tamura, 1990…) considered the human capital. Others (Romer, 1986 and 1990) take into account research and development or more broadly innovation technologies.

[4] The difficulties of that type of planning are underlined for example by Pollack-Johnson *et al.* (1990) for the US and Beltramo, Bourdon and Paul (1994, 1996) for the case of France.

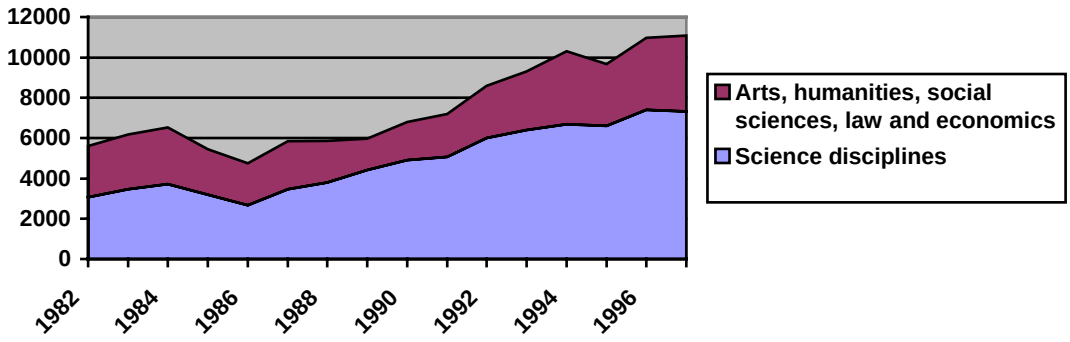
[5] The number of grants from the ministry of higher education and research doubled.

[6] CIFRE (Convention industrielle de formation par la recherche): PhD Graduates take part in an industrial agreement on training through research. PhDs that are funded and employed by a private firms to conduct their theses.

environment of the university tends to incite students to make a thesis. Actually, the PhD is the only diploma that give an access to academic positions. The relationships between PhD students and their supervisors can be analysed in terms of the implicit contracts theory (Stephan and Levin 1997). The supervisor attempts to develop his scientific visibility in hiring PhD students. But the PhD student will be rewarded by the help that his supervisor give him in attending academic position. In the French context of the 1990s, the incentives for students to continue their studies are high because of the low labour market prospects.

The number of theses roughly doubled between 1982 and 1996 (cf. figure 2). The number of PhDs awarded in sciences disciplines grew by 239 % and non scientific PhDs awarded grew by 148 % in the same period. The growth is particularly important between 1986 and 1994 for natural sciences. For the other disciplines, a rapid growth began at the beginning of the 90's.

Figure 2. Number of PhD awarded in France



Source: data from the DPD between 1982 and 1988 and from "l'observatoire des flux et des débouchés" (observation of thesis) after 1989. We grouped data between two categories: science and the whole social sciences.

We observe important differences between science disciplines[7] (cf. table 2). We observe that the growth is the most important in the field of mathematics and computer science between 1989 and 1996. But, the increase of PhD graduates in the other science disciplines is important. We note that almost all the growth is concentrated between 1989 and 1994, at the exception of mathematics and computer science where it took place at the end of the period. Another decomposition would have shown that the increase in the number of PhD graduates had been particularly important in chemistry, geology and biology.

[7] The number of PhD graduates in law, political science and economics: 545 in 1989, 1139 in 1996. And in arts, humanities and social sciences: 1017 in 1989, 2414 in 1996.

Table 2. Number of PhD graduates and annual growth rates (1989-96)

	1989	1990	1991	1992	1993	1994	1995	1996	1994/89	1996/94
Maths, computer science	198	233	247	296	356	418	364	868	16,1	44,1
Physics, chemistry, engin.	2652	2901	2540	3629	3772	4162	3999	4024	9,4	-1,7
Geology, astronomy	128	335	313	418	410	439	453	499	28,0	-6,7
Biology, health studies	1223	1436	1409	1664	1843	1972	1882	1999	10,0	0,7
Total	4401	4905	5067	6007	6381	6991	6698	7410	9,7	3,0

Source: Observatoire des Flux et des Débouchés (Thesis Observatory).
Notes: 1994/89: annual growth rates (%) between 1989 and 1994. 1996/94: annual growth rates (%) between 1994 and 1996.

1.2. The demand for scientists

This part of the scissors is really more difficult to assess and to forecast. One study (Beltramo *et al.* 1996) attempted to forecast the demand for PhD graduates at the beginning of the 1990s and concluded to a future excess of scientific graduates. Here we simply give some elements on the transformations in the French innovation system that can have an influence on the demand for scientists.

PhD graduates positions are essentially concentrated in the public and academic sectors. The specific position of the PhD diploma in the French higher education system is responsible for this fact. More than a half of the PhD graduates have researcher positions in the public and academic sectors after finishing their theses. Few of them have jobs in the private sector. Thus, demand for scientists is really difficult to forecast because it depends greatly on discretionary public policies.

For the part of PhD graduates who have positions in the private sector, we can note that the demand is driven by the evolution of R&D expenditures. In the 1990s, the economic growth was relatively slow during all the decade and R&D expenditures followed approximately the GDP growth. Thus, demand for scientists stayed relatively weak during all the 1990s. We are not able to provide estimations of the elasticity of the demand for scientists – because the definition of this category is impossible to make seriously – to the R&D expenditures.

In the private sector, researcher positions are traditionally devoted to graduates from engineering schools. The hiring in the private sector depends on the position in the business cycle. When the economic growth is stronger, like at the end of the 1990s, employment conditions are better, especially for higher education graduates. A greater part of PhD graduates attempts to join the private sector where they are in competition with graduates from engineering schools. The graduates from engineering schools, with broader competencies, are traditionally better prepared to enter in the private sector.[8]

[8] But, this category is more and more heterogeneous. Some of the engineer graduates have also increasing difficulties in entering the labour market.

1.3. The equilibrium situation: a underemployment situation ?

We can only test indirectly our hypotheses with two surveys carried out by Céreq in 1997 and 1999. These surveys concerned the labour market prospects for higher education graduates. The situation of higher education graduates can be followed during three years (43 months) after the end of their studies. We use a specific part of those surveys that concerned PhD graduates, other than PhDs in medicine, who finished their theses respectively in 1994 and 1996.

1.3.1. The selected samples: presentation of the data

To homogenise the data, we have selected two samples of French PhD graduates in science disciplines, less than 35 years old respectively in 1997 and 1999. We have divided the samples in sub-samples that are relevant for our analysis. The nature of the diploma before the PhD (graduates from a engineering school or not) and the nature of the thesis funding (Cifre or not) are used to select sub-samples. Some PhD graduates, before their PhD, are graduates from engineering schools (*Grandes Ecoles* and other *Ecoles d'ingénieurs*). The others come from the traditional tracks of the universities (*maîtrise*). PhD Cifre are PhD graduates that take part in an industrial agreement on training through research. These PhDs are funded and employed by a private firms to conduct their theses and the private firms receive a subsidy from the Technical Research National Agency (Ministry of Higher Education and Research) for hiring the young researcher. We use these two categories, as a first step for our analysis, because the PhD graduates with or without these attributes (graduates from engineering schools and PhD Cifre) have really different background, competencies and labour market prospects.

Thus, we have four categories of PhD graduates in sciences disciplines :

- PhD graduates without any of the attribute (nor engineer, nor Cifre)
- PhD graduates who have a diploma from a engineering school (previously to their doctorate)
- PhD Cifre
- PhD Cifre and who have a diploma from a engineering school

Table 3. Samples selected of PhD graduates in science disciplines

	Graduates in 1994			Graduates in 1996		
	Male	Female	Total	Male	Female	Total
PhD	182	86	268	517	356	873
PhD, engineer	58	20	78	160	68	228
PhD, Cifre	107	59	166	71	34	105
PhD, Cifre-engineer	78	26	104	89	24	113
PhD, total	**426**	**191**	**616**	**837**	**482**	**1319**
Grad. from eng. schools	384	130	514	224	52	276

Source : Céreq 1997 and 1999. Our samples. French PhD graduates in science disciplines less than 35.

The description of the samples is presented in Table 3. As a way of comparison, we will sometimes present labour market prospects for engineering school graduates. These graduates are the closest from PhD graduates in terms of competencies even if they are not especially

prepared to have research positions. Actually, the graduates from engineering school can pretend to have positions that are similar to PhD graduates. The greater part of them are employed in the private sector in high level positions. In the first part of their career, they are often employed as technical staff at a high level position. And after few years of employment, they often attend management positions.

1.3.2. Labour market prospects for PhD graduates

The labour force participation rates and the unemployment rates of PhD graduates three years after the end of their thesis are presented in Table 4. The participation rates are really high for PhD graduates. They are the highest among higher education graduates. Really few of them are out of the labour force. Not surprisingly, there are few differences between male and female participation rates.[9]

Unemployment rates of PhD graduates are important three years after the end of the thesis. An improvement of the situation of PhD graduates is observed between 1997 and 1999. PhD graduates benefited from the improvement of the economic situation at the end of the 1990s in France. After performing poorly on 1990-1996 – the 1993 recession was particularly violent –, the French economy knew a growing activity and a growth that was richer in jobs. Job creation revived from 1997, putting an end to ten years of labour market deterioration. This situation led to a progressive disappearance of cyclical unemployment.

Table 4. Situation three years after finishing studies (%)

	Graduates 1994 Rates observed in March 1997						Graduates 1996 Rates observed in March 1999					
	Participation			Unemployment			Participation			Unemployment		
	M	F	T	M	F	T	M	F	T	M	F	T
PhD	96.7	94.2	95.9	15.9	17.3	16.3	95.1	94.3	94.8	8.6	14.9	11.2
PhD, engineer	100	90.0	97.4	12.1	16.7	13.2	96.8	95.6	96.5	6.3	5.9	6.2
PhD, Cifre	99.1	91.5	96.4	5.7	9.3	6.9	97.2	97.0	97.1	8.1	13.5	10.0
PhD, Cifre-engineer	100	100	100	0.0	3.9	1.0	98.9	100	99.1	2.9	5.7	3.6
PhD, total	**98.4**	**93.7**	**96.9**	**9.8**	**12.9**	**10.7**	**96.1**	**95.0**	**95.7**	**6.8**	**12.9**	**9.0**
Grad. from eng. schools	90.6	86.9	89.7	7.5	10.6	8.2	91.1	82.7	89.5	2.9	7.0	3.6

Source : surveys carried out by Céreq (1997 and 1999). Our sample. Our calculations.
Participation : labour force participation rates. Unemployment : unemployment rates. (International Labour Organisation's definitions). M = male, F = female, T = total.

Higher education graduates are particularly sensitive to economic growth. Their entry in the labour market is facilitated by the recovery of the economy. PhD graduates are less sensitive than the other higher education graduates to economic growth. A great part of them are employed as public or academic jobs which are essentially driven by discretionary public policies. On the contrary, graduates from engineering schools benefited particularly from the important job creation in the private sectors.

[9] For few years now, male and female age participation profiles have become more and more similar.

Unemployment rates are really different between the four categories we isolated. PhDs who are graduates from engineering school and PhDs Cifre are less unemployed three years after finishing their theses than the other PhD graduates. Important differences by genre are observed. Female have always higher unemployment rates.

Unemployment rates have been computed by disciplines (Table 5). PhDs in chemistry, geology and biology have the highest unemployment rates. An explanation of these differences can be found in the evolution of the number of PhD graduates.[10] Actually, these three disciplines were concerned by an important growth in the number of PhD graduates before 1994. The PhD graduates in computer science have the lowest unemployment rates. The development of the software and hardware industries during the last years can explain this situation.

Table 5. Unemployment rates in March 1999 for 1996 PhD graduates (en %)

	Unemployment rates, March 1999
Maths, physics	6.3
Chemistry	14.0
Computer sciences	2.0
Electronics, engineering	7.4
Geology	15.4
Biology	11.1

Source : Céreq 1999. Our calculus.

Three years after completing their theses, less than a quarter of PhD graduates have temporary jobs (Table 6). Between 1997 and 1999, the increase in the proportion of temporary positions is essentially due to the rise in post-doctorate positions. PhDs who have links with the private sector (engineer and/or Cifre) are in a less precarious situation. And we could see (the results are not reported here) that females are in a less favoured situation than males.

Table 6. Labour market prospects for PhD graduates

	Graduates 1994 Employment situation, March 1997			Graduates 1996 Employment situation, March 1999		
	Permanent	Temporary	Postdoc	Permanent	Temporary	Postdoc
PhD	75.4	17.3	7.3	69.5	15.3	15.2
PhD, engineer	85.6	15.4	0.0	80.1	9.2	9.7
PhD, Cifre	83.7	15.6	0.7	89.4	9.4	1.2
PhD, Cifre-engineer	94.0	5.0	1.0	96.2	1.9	1.9
PhD, total	**82.5**	**14.2**	**3.3**	**75.6**	**12.5**	**11.9**
Grad. from eng. schools	89.0	11.0	0.0	94.5	5.5	0.0

Source : Céreq 1997 and 1999. Our samples. Percentage of temporary jobs, post-doctorate and permanent positions for the PhD graduates who had a job respectively in March 1997 and March 1999.

[10] But we will see that this explanation is not sufficient to account for the unemployment differencies between PhD graduates.

For few years now, post-doctorates have been on the increase, notably in the scientific disciplines where the entry in the labour market is more difficult. These postdoc positions are waiting positions for PhDs who have low labour market prospects. Post-doctorate, often made abroad (68% of postdoc are made abroad[11]), is also a mean for PhDs to increase their competencies. In some disciplines, the postdoc is a necessary step after completion of the PhD, a sort of "rite of passage" for young researchers. More than a quarter of PhD graduates made a postdoc on the period of three years after the end of their theses (Table 7). People who plan a career in academia (PhD who are not Cifre) have the higher proportion of postdoc. Postdoc has become the general proving ground for academic excellence but it concerns less people who intend to enter the business sector. Half of individuals who are employed in the public sector three years after the end of their thesis had been postdocs, for only 23% for people who are employed in the private sector. The part of individuals concerned by postdocs increased between 1997 and 1999. On the 43 months of observation, the average duration of post-doctorate is 17 and 20 months respectively for PhDs who were graduated in 1994 and 1996.[12] Some commentators express concern about the increasing duration of postdoc positions.[13]

Table 7. Part of PhDs concerned by post-doctorate on three years

	Graduates 1994		Graduates 1996	
	None	One or more	None	One or more
PhD	64.9	35.1	58.2	41.7
PhD, engineer	70.5	29.5	66.0	34.0
PhD, Cifre	84.9	15.1	77.6	22.4
PhD, Cifre-engineer	88.5	11.5	85.8	14.2
PhD, total	**75.0**	**25.0**	**65.5**	**34.5**

Source : Céreq 1997 and 1999. Proportion of PhD graduates who has not done a post-doctorate and who has done one or more post-doctorate.

1.3.3. An overproduction of scientific PhD graduates in some fields ?

We want to test (indirectly) the hypothesis of a overproduction of PhDs in science disciplines in the 1990s in France. This hypothesis is an indirect test of the equilibrium

[11] We could only calculate this proportion for 1994 graduates. The information is not present in the survey of 1999. In France, and more generally in the other European coutries, postdocs abroad are considered as a necessity for your CV. This situation is different from the US and UK cases where individuals are able to stay home. For the French case, the question remains to know wether the postdoc favours the entry in the labour market. In our two surveys, the short period of observations allows us to answer this question with difficulty.

[12] The average duration is calculated only for people who have made one or more post-doctorate.

[13] The same concern can be found at the international level. See for example, the articles in *Science*, *Nature* or *The Chronicle of Higher Education*. For example : Balter Michael et Dennis Normile (1999), « Europeans who do postdocs abroad face reentry problems », Science 285, 5433, Sep. 3, pp.1524-26, Nerad Maresi et Joseph Cerny (1999), « Postdoctoral Patterns, Career Advancement, and Problems », Science 285, 5433, Sep. 3, pp.1533-35, Normile Dennis (1999), « New Career Paths for Young Scientists », Science, Apr. 9, 284, 5412, pp.233-234, Magner Denise 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, Schneider Alison (2000), "Seeking an end of 'postdoc hell'", The Chronicle of Higher Education 47(3), Sep 22; Anonymous (1999), "What's up postdoc?", Nature, Feb 25…

perspective. The evolution of the supply and demand sides of the labour market for PhD graduates contributes to the low labour market prospects for PhD graduates. For the supply side: there was a clear rise in the supply of PhD graduates in the 1990s in France. For the demand side: the limitation in the number of posts in the academic and public research sectors and the slow growth of the R&D expenditures are the two main elements that are likely to explain the slow rise in the demand for scientists.

To test this hypothesis, we make two main assumptions :

- on a local labour market, an overproduction of graduates can be identified by important underemployment or unemployment situations. We assimilate the scientific labour market as a specific labour market in which the PhDs would like to enter. We suppose that PhD graduates express strong preferences for entering the academic and public research sectors. The specific institutional situation of PhD graduates in the French higher education system – the division between the graduates from the *grandes écoles* and the PhD graduates from the universities – permits us to make this hypothesis. The implicit contract between PhD students and supervisors incite PhDs to try to enter the academia preferably. This implicit contract is still relevant even if the low labour market prospects can weaken it.

- we suppose that PhDs from different disciplines have the same (strong) preferences for entering the academic and public research sectors, and we suppose that these preferences are stable over time. That is why we control for other variables that are likely to influence these preferences (to have a PhD Cifre, to be graduate from a engineering school, to have done a period in a private firm during ones thesis…).

The indirect test of a overproduction of PhD graduates consists in the estimation of the effect of being graduate in a specific field on the probability of being in different situations in the labour market, when controlling for the other variables that are likely to influence the entry in the labour market. For example, we would like to determine if being graduates in a specific discipline has an effect on the probability of being unemployed three years after the end of the thesis. If the answer is yes, then we would conclude that there was an overproduction of PhD graduates in this particular field. Or we could say that there is an occupational mismatch in this particular field on the labour market.

For that purpose, we estimate a multinomial logit model. We were able to estimate this model only for PhDs graduated in 1996.[14] MNLM applied for multiple nominal outcomes (polytomous outcome variables). They are used to analyse unordered categorical response variables. The effects of the independent variables are allowed to differ for each outcome of the dependant variable. Here, the dependent variable y_i has four outcomes that depict the labour market situation of the individuals in March 1999 (three years after the end of their thesis) :

- $y_i = 0$ if the individual is in a permanent position and at a high level position (professional, researcher or engineer in the public or private sectors, academics). It is considered as the baseline category (the reference).

[14] The scientific disciplines were not well defined in the survey of 1997 (graduates 1994).

- $y_i = 1$ if the individual has a permanent contract but "under-qualified", i.e. technician, craft, blue collar…
- $y_i = 2$ if the individual is in a temporary position, whatever the level is.
- $y_i = 3$ if the individual is unemployed.

Thus, we want to estimate the following model :

$$\begin{cases} \Pr[y_i = 0 | x_i] = \dfrac{1}{1 + \sum_{j=1}^{3} \exp(x_i' \beta_j)} \\ \Pr[y_i = m | x_i] = \dfrac{\exp(x_i' \beta_m)}{1 + \sum_{j=1}^{3} \exp(x_i' \beta_j)} \quad \text{for } m = 1,2,3 \end{cases}$$

where y_i denote the polytomous outcome variables with our 4 categories for each individual i. $\boldsymbol{\beta}_m = (\beta_{0m} ... \beta_{Km})'$, the vector of parameters to estimate, 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 3(K+1) parameters.

The independent variables are of three sorts :

- individual characteristics : genre, age, socio-economic background… that are likely to influence the labour market prospects of PhD graduates
- variables to account for the competencies and the experience of PhD 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 thesis funding (from the Ministry of Higher Education, Cifre…), the structure where individual make ones thesis (laboratory of the Scientific National Research Centre…), the previous diploma before PhD (graduates from a engineering school), the different activities during thesis (training period in a firm, teaching activities, *moniteur*…), the duration of the thesis, the post-doctorate…
- the fields of the PhD; these dummy variables account for the specific influence of scientific disciplines and indirectly for the overproduction or occupational mismatch in a particular field. The reference is constituted by the PhD in mathematics and physics.

Table 8 presents the maximum likelihood estimation of a model. We estimated other models with different sets of explanatory variables. At least the sign and the significance of the coefficients were similar to those reported here.

We just make comments on the coefficients related to scientific disciplines. It is clear that the probability of being unemployed (vs. employed as professional, in a permanent contract) is affected by the scientific field. On the contrary, the probability of being on the two other situation i.e. having a "under qualified" job or being in a temporary position, does

not depend on the PhD disciplines[15]. The odds of being unemployed (vs. employed as a professional and in permanent position) for PhD in biology and chemistry are 2.3 times as high as those for PhD in physics and mathematics, other things equal. The corresponding odds for PhD in geology and astronomy are 3.4 times as great as those for PhD in maths and physics. On the contrary, PhDs in computer science have a lower probability of being unemployed (odds equal to 0.12).

Thus, when controlling the effects of the other variables, the scientific discipline has a strong influence on the probability of being unemployed. It is clear that, at the end of the 1990s, the scientific field plays a role in the labour market prospects for PhD graduates. This may be the consequence of a overproduction of graduates in some fields or a occupational mismatch in the labour market.

Table 8. Estimation of the multinomial logit model. Probability of PhD graduates in science disciplines being in one of the four situation for

Number of observations	1186		
	(1)	(2)	(3)
Constant	0.0501 (3.4417)	-1.8139 (1.8164)	-7.3241*** (2.2060)
Female	-0.6211 (0.4421)	0.4943*** (0.2019)	0.5210** (0.2407)
Age in 1996 (in years)	-0.0624 (0.1264)	-0.0123 (0.0669)	0.1352* (0.0795)
Graduate from a engineering school	-0.3988 (0.4686)	-0.4552* (0.2478)	-0.7592** (0.3277)
Cifre	-1.3031** (0.6745)	-0.6729** (0.3123)	-0.1148 (0.3455)
Thesis funding from the Ministry of Higher Education and Research	-0.7099* (0.4274)	-0.0912 (0.2225)	0.5347** (0.2729)
Moniteur	0.2553 (0.4495)	-0.3749 (0.2535)	-0.6641** (0.3115)
At least a training period in a private firm during thesis	-1.2651* (0.7619)	-0.5830* (0.3222)	-1.3119*** (0.5431)
Duration of thesis (in months)	-0.0104 (0.0238)	0.0206** (0.0112)	0.0250** (0.0131)
PhD in biology, chemistry	0.2132 (0.4475)	0.2472 (0.2368)	0.8331*** (0.3209)
PhD in geology, astronomy	-0.1979 (1.0854)	0.5084 (0.4272)	1.2210*** (0.5057)
PhD in computer science	-0.4393 (0.6819)	-0.5310 (0.3746)	-2.1577** (1.047)
PhD in electronics, engineering	-0.3388 (0.6234)	-0.7127** (0.3729)	0.4495 (0.4061)
-2 log likelihood	1527.79		

Source : Céreq 1999. Maximum likelihood estimation of a multinomial logit model. Coefficients with standard errors in parentheses. For the PhD discipline, the reference is constituted by the mathematics and physics. Significance levels of the coefficients : * significant at 10%, ** significant at 5%, *** significant at 1%.

[15] except for the influence of PhD in engineering and electronics on the probability of being in a temporary position.

Section II. PhDs in the French innovation and technological system

The equilibrium model developed in the previous section is not sufficient to understand the labour market prospects for PhD graduates. The specific situation of PhD graduates in the higher education and research system and in the innovation and technological system has to be considered here.

The transformation in the labour market prospects for scientists were previously explained by three main facts: the increase of PhDs awarded in France during the 1990s, the decline or, at least, the stagnation of public research expenditures and the important hiring of graduates in some departments of public and academic institutions in the 1970s. The difficulties in the labour market for some scientific PhD graduates were explained by these exogenous facts. On the contrary, we consider here the labour market for scientists as a part of an innovation system in evolution and we try to predict these facts endogenously. PhD graduates who have difficulties entering the labour market are those who have not developed their relations with R&D partners during their thesis or those who have not broad competencies (others than their highly specific competencies).

We develop some elements on the recent evolution of the innovation system and we analyse briefly their consequences on the employment perspectives of PhDs. Then, we present the specific situation of PhDs in the innovation and technological system. Finally, we test our hypothesis: what are the characteristics that have to be held by PhD graduates to enter in good conditions in the labour market ?

2.1. The transformations in the scientific and technological systems

The relationships between the French public science system (academic and public laboratories) and the private sector are traditionally highly concentrated (Papon 1998). The relations between the two poles are traditionally dominated by the *grands programmes* in a few high technology areas. Contractual relations are essentially developed between large private firms and public agencies.[16] This situation is evolving. Public and academic laboratories are more and more engaged in network collaboration.

The French scientific and innovation systems can be analysed with the help of the linear model of innovation. The hypothesis is that there exists a clear division of labour between academic or public science and technology, basic and applied science, private and public science… A causal chain link basic science, applied science and technology or development. The clear division between the academic world on the one hand and some national agencies on the other is not still relevant. Until the 1990's, academic researchers and researchers from the Scientific National Research Centre (CNRS) were in charge of basic science. The CNRS scientific orientations are taken relatively independently by a national direction of scientists. Applied science and technological development were done for a great part by national scientific and technology agencies (INRA, CEA, INSERM…), under the control of public policies. The national agencies have contracts with some large private firms. The R&D activities are thus concentrated in a few industrial firms (OST 1998). The military industries that depend directly on the government are also a key element in the R&D activities at the

[16] At the political level, recent debates emerged about the consequences of the specific structure of the French innovation system (Guillaume 1998, OST 1998, Destot 2000).

national level. The CEA for example has a strong influence on the orientation of the energy public policy and defence.

In the triple-helix typology, we could assimilate the French innovation system until the end of the 1980s with the triple helix I configuration. “In this configuration, the nation sate encompasses academia and industry and directs the relations between them” (Etzkowitz and Leydesdorff 2000, p.111).

The chain-linked model developed by Kline and Rosenberg (1986) was the first attempt to analyse the complex interactions between the different partners of the innovative activity. Kline and Rosenberg underlined that the innovation processes is “neither smooth nor linear” (p.285). Innovation does not come from the technology pole or the demand pole. It is a the result of multiple interactions between heterogeneous actors with specific historical background and with specific absorptive capacity.

The division between academic or basic science and applied science is not now so well established. Various schemes of collaboration have emerged since the end of the 1980s. For example, we assist to the creation of laboratories jointly funded by the CNRS and industrial firms. National agencies are also more interested in developing their links with scientific or academic laboratories. Even if a half of national R&D expenditures are always funded by the State (OST 1998), the centralisation of the system is diminishing.

Collaboration between public science and private firms is facilitated by the development of new specialised knowledge-intensive industries. These institutions facilitate transfers of knowledge between public and private research partners (Carayannis *et al.* 2000). Cross organisational and institutional entities begin to play an important role in the diffusion of knowledge inside the French innovation system. These modifications in the innovation processes have important consequences on the scientific manpower. We try to link the evolution of the labour market prospects for scientists and the transformations in the innovation processes in the French economy. The new bridging or hybrid institutions enlarge the internal scientific labour market. They are an extension of the scientific community for the academic and public research sector (Lam 2000).

2.2. The scientific manpower in the French innovation system

In the French political and administrative systems, the *grands-corps de l’Etat* have a predominant position. They come from the *grandes écoles*. Some of them have scientific backgrounds (*Ecole Polytechnique*, *Ecole Centrale*…) and have a direct influence on the scientific and innovation system. On the contrary, PhD graduates are traditionally employed in the academic and public scientific institutions (universities, CNRS laboratories…). Few of them have positions in the private sector. Career prospects are essentially concentrated in the public sector. In our two surveys, half of PhD graduates have positions in the public or academic sectors (Table 9). There are important differences among PhD graduates. PhDs who have a diploma from a engineering school and PhD Cifre are less employed in the public sector. And only 10% of the graduates from engineering schools are employed in the public sector.

But labour market prospects for PhDs are slowly evolving with the transformations in the French innovation and technological system. Some of the bridging institutions based their R&D activities on young scientific PhD graduates. The availability of important cohort of

young PhD graduates in scientific disciplines since the beginning of the 1990s is, in our sense, the base of the new French innovation system. For example, the increasing duration of postdoc positions give to these intermediate structures the possibility of hiring highly qualified scientific manpower at low cost. The hiring of scientific manpower can be an efficient mean of knowledge diffusion. The extended scientific labour market is, in our view, a mean, not only to transfer knowledge between firms (Malo and Geuna 1999), but in the broader perspective of the triple-helix model, a mean to increase the efficiency of knowledge diffusion between public, academic and private partners. But, this evolution is not general. Few sectors and few regions are for instance concerned by these trends. These evolutions seem to be geographically concentrated essentially in high-tech poles.

Table 9. Positions and main activities three years after graduation (%)

	Graduates 1994 Situation in March 1996				Graduates 1996 Situation in March 1999				
	High level	Public sector	Main activities		High level	Public sector	Main activities		
			Res., comp.	Teach.			Res.	Comp.	Teach.
PhD	92.6	67.9	51.6	41.9	90.2	60.7	52.8	9.8	29.7
PhD, engineer	95.6	60.0	63.6	28.8	94.7	51.9	66.0	10.1	16.8
PhD, Cifre	96.7	31.5	70.5	15.4	93.1	17.2	64.3	13.8	5.8
PhD, Cifre-engineer	96.1	28.2	75.9	12.6	98.1	19.7	72.9	9.4	5.6
PhD, total	**94.8**	**49.1**	**62.5**	**27.2**	**92.0**	**51.9**	**57.9**	**10.1**	**23.3**
Grad. from eng. schools	91.5	10.7	57.7	8.0	91.9	8.9	43.3	23.9	2.1

Source : Céreq 1997 and 1999.
High level positions : proportion of graduates in high level positions.
Public sector : proportion of jobs in the public sector (large definition : State, local government, universities and public research institutions).
Main activities : main activities declared by individuals :

- Res. : research activities
- Comp. : computer activities
- Teach. : teaching activities (lecturing)

The greatest importance of innovation and research, in a context of globalisation, is transforming the innovation processes in the economy. The creation and diffusion of knowledge are evolving toward a more interactive mode. New intermediate research institutions are emerging and new links appeared between the three spheres: public, academic and private sectors. Consequently, we assist to important transformations in the scientific internal labour market. The scientific internal labour market is broader: it involves numerous institutions that take part to the innovation processes. The internal labour market plays a renewed role with the complexity of the interactions between the innovation partners. Thus, professional trajectories of young scientists are modified. The development of non tenured jobs and high unemployment are the two main facts that underline the difficulties that young scientists face to enter the labour market. In this context, young PhDs graduates who have not specific characteristics may have low labour market prospects.

2.3. The need to have specific characteristics

The employment perspectives in the academia are limited. Thus, PhD students must have specific competencies or characteristics to enter the labour market in good conditions. They must take part to specific networks that they construct during their thesis by the informal relations with the scientific community. The implicit contract between PhD students and research units, or between PhD students and supervisors, seems to be broken because the perspectives of employment are limited in the "traditional" (academic or public research) sectors.

Thus, we want to test a hypothesis : do PhDs have to hold specific characteristics to enter the labour market in good conditions ?

Our first estimation of the MNLM in the previous section give us already some indications about the answer to this question. Here, we estimate models for our two surveys. We do not include variables related to scientific disciplines, because these variables are not available for our survey of 1997. We test different sets of independent variables and we present models with few explanatory variables here (Table 10). But these models could have been estimated with exactly the same variables for our two surveys. That is interesting because we can observe the influence of the same variables on two cohorts. Then we are likely to compare the "evolution" of the effects of the different variables and to determine if we observe the same effects on a longer period.

As in the first model of Table 8, the endogenous variable is a polytomous variable with four outcomes (see the presentation before) which depict the labour market situation of individuals three years after the end of their theses.

PhDs 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[17], these variables decrease the probability of having a low level position, being in a temporary position and being unemployed (vs. being employed in a permanent position as professional). These variables have roughly the same effects for the two cohorts. During their thesis, PhDs who worked in the private sector or PhDs who developed their relationships with a private firm have less difficulties in entering the labour market. PhDs who were previously graduated from a engineering school 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, PhDs with strong relations with the public and academic research sectors have low labour market prospects. The funding from the Ministry of Higher Education and Research has no effect (for 1994 PhD graduates) or has a positive effect on the probability of being unemployed (for 1996 graduates). This variable is not sufficient to facilitate the entry in the labour market. PhDs must have other characteristics. For example, they have to be *moniteur*[18] (about assistant professor). The odds of being in a under qualified

[17] We have not enough room here to comment more precisely the results. You should note however that some variables are not significant at the 10% level.

[18] The moniteur are chosen among PhDs who are funded from the Ministry of Higher Education and Research.

post, being in a temporary position and being unemployed are decreased if the individual was *moniteur* during ones thesis.

Other models, not presented here, were estimated with more variables. For example, the variable 'research unit from the National Research Center (CNRS)' has a positive effect on the probability of being in temporary position or of being unemployed (but the effect was generally limited and most of the times this variable was not significant). This variable could be considered as a signal of the quality of research led by the PhDs. But PhDs who belonged to the CNRS during their thesis also developed their relations with the public and academic sectors. And these relations are not sufficient to ensure high labour market prospects.

We also tired to introduce a dummy variable for the post-doctorate. But, the results were not satisfactory. Actually, the period of observation (three years) is too short to see the consequences of the postdoc on labour market prospects.

Table 10. Estimation of multinomial logits for PhD graduates in science disciplines

	Graduates in 1994			Graduates in 1996		
Number of observations	599			1186		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	-2.1822***	-0.9520***	-0.9047***	-2.1153***	-0.6382***	-2.0070***
	(0.4225)	(0.2464)	(0.2722)	(0.2510)	(0.1345)	(0.2083)
Female	0.9190**	0.4353*	0.3304	-0.5739	0.3050**	0.7187***
	(0.3952)	(0.2353)	(0.2967)	(0.3694)	(0.1604)	(0.2063)
Graduate from a engineering school	-0.9798*	-0.7532***	-0.8360**	-0.6032	-0.8395***	-0.9733***
	(0.5659)	(0.2772)	(0.3642)	(0.3956)	(0.2078)	(0.2925)
Cifre	-0.6981	-0.4841	-1.0784**	-0.8018*	-1.2933***	0.0312
	(0.6244)	(0.3248)	(0.4387)	(0.4757)	(0.2745)	(0.2966)
Funding from the Ministry of Higher Educ.	0.6514	0.3094	0.0819	-0.7537*	-0.5531***	0.4504**
	(0.4622)	(0.2958)	(0.3386)	(0.4006)	(0.1886)	(0.2391)
Moniteur	-1.2150**	-0.7512**	-1.1230***	0.2351	-0.5215**	-0.7459***
	(0.5553)	(0.3353)	(0.4097)	(0.4417)	(0.2407)	(0.3011)
At least a training period in a private firm	-1.0713*	-0.2322	-0.9400**	-1.3353*	-0.9325***	-1.2742***
	(0.6446)	(0.3169)	(0.4338)	(0.7407)	(0.2959)	(0.5293)
-2 log likelihood	1086.07			2076.48		

Source : estimations of two multinomial logit models. The first one for PhD graduates who finished their theses in 1994 and the second one for those who finished their theses in 1996.
Estimation of the relative probability of being in one of the four situations three years after finishing thesis (that is in 1997 and 1999 respectively). The reference is the situation where PhD graduate has a high level post with a permanent contract. Three outcomes have to be assessed relative to this reference :

- (1) : to have a permanent position but not a high level post
- (2) : to have a temporary position (whatever the level position is)
- (3) : to be unemployed

Estimation of the coefficients with standard errors in parentheses. Significance levels of the coefficients : * significant at 10%, ** significant at 5%, *** significant at 1%.

We confirm a part of our hypothesis: at the end of the 1990s, we assist to a reinforcement of the scientific internal labour market. We show that PhD graduates who do not have specific characteristics that signal specific competencies experience low labour market prospects.

Conclusion

Two major conclusions can be drawn from this paper. On the one hand, in the 1990s in France, PhD graduates have low labour market prospects in some scientific fields. In our multinomial logit model on the entry in the labour market of PhD graduates, the scientific discipline is far from being without effect. This effect can be interpreted as a past overproduction of PhD graduates in some fields. In a context of slow economic growth and in a context of limitation in the number of academic and public research positions traditionally devoted to PhD graduates, this overproduction increases the difficulties of PhD graduates in the labour market. In the scientific labour market, we are in presence of an occupational mismatch.

On the other hand, this effect of scientific field is not sufficient to explain the low labour market prospects for PhDs. Institutional factors, such as the specific position of PhDs in the innovation and technological systems, explain a part of these difficulties. The recent transformations in the innovation systems could increase the difficulties to enter the labour market for PhD graduates who do not have specific characteristics. PhDs who have not developed their relations with the innovation community or PhDs who do not have broad competencies are likely to experience lower labour market prospects than those who have the broad competencies required by the new innovation context.

Appendix : short description of doctoral studies

Doctoral studies

University tracks are divided into three levels (cycles). The first cycle is constituted of the two first years at university. The second cycle is constituted of the third (*licence*) and the fourth (*maîtrise*) years. At the third cycles, there are the *DESS* (*Diplôme d'études Supérieures Spécialisées*, Diploma of specialised higher education studies) and the *DEA* (*Diplôme d'études approfondies*, diploma of advanced studies). The *DEA* can be considered as the first year of the doctoral studies. The PhD is obtained in three or four years after the *DEA*. The PhD include the writing of a doctoral thesis which is publicly defended.

The access to the DEA is based upon the results in *maîtrise*. A small proportion of students continue their studies in PhD after they pass their *DEA*. About less than a half of students that obtained a *DEA* continued in PhD in science disciplines. Transition rates are weaker in the social sciences and humanities. One can considers the DEA as an introduction to research activity.

The university system coexists with the *Grandes Ecoles*. There are schools in scientific disciplines (*écoles d'ingénieurs* = engineering schools) and in business field (*écoles de commerce* = business schools). The access to this schools is selective. Students are awarded their diploma after 5 years. Graduates from engineering schools can access a *DEA* in the last year of their cursus.

*CIFRE (*Convention industrielle de formation par la recherche*)*

PhD graduates that take part in an industrial agreement on training through research. PhDs that are funded and employed by a private firms to conduct their theses.

*Monitorat (*Monitorat d'initiation à l'enseignement supérieur*) = assistant professor*

A *moniteur* is a PhD student chosen from the PhD students granted by the ministry of higher education. The *moniteur* benefits of vocational training for the different tasks of a lecturer in higher education, through teaching practices, lecturing at the first level of universities.

*ATER (*Attaché Temporaire d'Enseignement et de Recherche*)*

Temporary teaching and research activities. The PhD holder that has just finished ones thesis may obtain a temporary position while waiting for his entry in the academia.

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