



## National science training policy and early scientific careers in France and the United States

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### Abstract

The economic health of nations and regions is increasingly coming to rest on the scientific and technical labor force conducting scientific research. As such, enormous social resources are directed to educating and training those who will fire the engines of economic growth. In the first part of this paper, we compare recent investment in the scientific and technical labor forces by two giants of nationally-supported research endeavors: France and the United States. We find that France is more invested in scientific and technical training, but that both nations invest directly and indirectly in the scientific and technical labor force. French policy is more likely to support the individual graduate student directly through a national grant, while graduate students in the US tend to rely indirectly on federal support through research grants to other researchers. We then use duration models on individual data to predict entry into a permanent academic position within three years of completing a Ph.D. We do not find that industrial support of graduate training has any effect on later success in obtaining a position. There is, however, evidence of different academic labor markets operating in each country. In France, entry into a position has not depended on period factors, while in the US more recent cohorts have been more successful in obtaining permanent employment. Furthermore, postdoctoral positions in France delay or deter academic careers, but have no impact on entry in the US: this suggests that two different modes of scientific human resources management operate in France and in the USA. In the USA, Ph.D.s are seen as an essential element in the process of knowledge transfer, and early mobility does not affect entry into permanent academic careers. In France, few incentives are given to encourage mobility, which merely deters the access to permanent jobs. Finally, we found that graduates of the most prestigious undergraduate institutions were systematically advantaged in obtaining permanent academic employment, suggesting that academic stratification occurs very early in the training path in each country. © 2004 Elsevier B.V. All rights reserved.

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### 1. Scientific labor force in modern industrial economies

The development of modern “knowledge-based” economies demands an expansion of educational training and attainment. This implies a *de facto* intervention in the labor market that transcends simple

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supply-demand functions of the older industrialism. Creation and placement of scientific and technical human capital (Bozeman et al., 2001) is the most significant mode of production and knowledge transfer in higher education. Public investment in an individual's scientific and technical human capital at the highest levels of attainment occurs over the period of a quarter century or more—well outside economic cycles and short and long-term planning horizons (Atkinson, 1990; Baker, 1992). This necessary misalignment between economic cycles and the requirements for a flexible scientific and technical workforce leads to several policy problems (Braddock, 1992).

In this paper, we address one particular aspect of educational policy: the intersection of postgraduate educational support with the development of individual scientific careers. To do so, we engage in a comparative analysis of French and US educational policy at the post-graduate level in the closing decades of the 20th century. Each of these countries is a major producer and employer of scientists, and at the forefront of developing knowledge economies. Studies of scientific careers have traditionally been decoupled from the social, political, and economic context of the young researchers (for exceptions, see Brode, 1971; Mangematin, 2000). We argue that it is impossible to understand the development of scientific careers without understanding science policy as it relates to early career development. We propose an approach that includes policy proxies as individual-level determinants of early career transitions to permanent academic employment. In particular, we examine how period effects, type of undergraduate institution, source of graduate support, postdoctoral training, and productivity affect the likelihood of obtaining a permanent academic appointment within three years of obtaining the doctoral degree.

## 2. Science and the scientific labor force: a comparative view

The United States and France are the first and fourth largest economies in the world, and are leaders in the development of science and information-based economies. The United States boasts the largest national output of annual science and engineering degrees, (27,000 in 2001), while France together with

her EU sister members England and Germany, exceed this output by 1000 doctorates per year (NSF, 2001a,b). The doctoral-level scientific labor force in the US numbers almost one million, and that of France at over 150,000. With the expansion of English as the “lingua Franca” of science, French scientists still publish an important share of scientific articles, which, nonetheless, remains lower than that of scientists from other EU countries, such as the UK or Germany (NSF, 2001a,b; NSF, 2002a,b). France's overall labor force is among the most productive in the world, and over 250,000 new companies are founded each year (L'Industrie Francaise 99/00). Together, France and the US invest a staggering amount in research and development: in 1993 (1987 constant dollars), the United States federal government financed \$134.4 billion of research, and France financed \$21 billion (NSF, 1996). In 1999, the total (private and public) R&D spending was \$244 billion in the USA, and \$29 billion in France (DPD, 2001). To put these French figures in perspective, France spent 2.19% of its GDP on R&D in 1999, while the USA spent 2.64% (DPD, 2001). Table 1 shows that R&D spending declined slightly as a percentage of gross domestic product during the 1990s. Despite this decline, R&D is a substantial component of each country's national expenditures. However, France will have to reverse this trend in the coming years, if it wants to play a major part in the building of a common European Research Area (ERA). This European initiative, launched at the Lisbon council in March 2000, states that, as a global entity, the EU should spend 3% of its GDP on R&D. Since the level in 1999 was only 1.9% (Commission of the European Communities, 2002), there is still a long way to go.

Romer (2002) emphasizes that, to have any impact on the economic well-being of a nation, spending on R&D must increase the total quantity of inputs that go into the innovation process, including human resources. Thus, researchers, scientists and engineers

Table 1  
Trends in total R&D spending (in % of the GDP) over the 1990s

	1991	1996	1998	1999
USA	2.72	2.54	2.60	2.64
France	2.37	2.30	2.17	2.19

Source: DPD (2001).

Table 2  
Percentage of French and US Ph.D. scientists by discipline over the 1989–1999 period

Year	France					USA				
	Percentage by discipline				Total number	Percentage by discipline				Total number
	Math., computer sciences	Physics and engineering	Earth, atmos., ocean	Life sciences		Math., computer sciences	Physics and engineering	Earth, atmos., ocean	Life sciences	
1989	16	48	8	28	4401	10	51	5	34	15200
1990	16	48	7	29	4905	10	52	4	34	16255
1991	16	50	6	28	5067	11	51	5	33	17217
1992	16	49	7	28	5979	11	52	4	33	17802
1993	12	53	6	29	6384	11	52	4	33	18254
1994	12	53	7	28	6991	11	52	4	33	18925
1995	12	52	6	30	6601	12	51	4	33	19227
1996	12	54	7	27	7413	10	52	4	34	19739
1997	12	53	7	28	7333	10	51	4	35	19581
1998	12	53	6	29	6981	11	50	4	35	19546
1999	12	53	6	29	6477	11	49	4	36	18193

Sources: DGRT (1995, 2000, 2001), NSF (2000).

are key elements in national innovation systems (Lundvall, 1992; Niosi, 2002), and the number of scientists trained in a nation is an additional indicator of this nation's commitment to R&D. Table 2 shows the proportion of Ph.D. scientists trained each year in France (left panel) and the United States (right panel) over the 1989–1999 period, as well as the total number of new graduates per year. For comparability reasons, only sciences are taken into account; social sciences and humanities are left aside. One can see that the number of French graduates has strongly increased in the beginning of the 1990s, to stabilize around 6500 graduates per year at the end of the period. Although the US annual figure is three times as large as the French figure, the smaller size of the French population indicates that a higher percentage of its population is trained at the doctoral level. However, research in Europe suffers from three main weaknesses: (1) an insufficient level of funding (which concerns both job creation and research projects), (2) the lack of an incentive structure to exploit economically its scientific output, and (3) a certain dispersal of resources (Commission of the European Communities, 2002). France, a prominent Member-State of the EU, can be said to suffer from the same weaknesses, as far as its R&D activities are concerned. This suggests that EU economies may be unable to absorb new knowledge workers fully.

### 3. National scientific training policies

Given the magnitude of French and American scientific training, it is useful to inquire into the specific policies and contexts that foster the development of new scientists and technical workers. The achievement of most modern democracies in basic primary and secondary education vastly exceeds that of the United States. At the same time, few would argue against the assertion that the American university system, and in particular its system of postgraduate training and research, is the main standard by which advanced scientific and technical training is compared. In the years following World War II, the US model of doctoral studies emerged as the dominant educational paradigm. Furthermore, it attracted many scientific immigrants to its shores, a pattern continued today. Despite some similarities in training models, France and the United States diverge in the means by which graduate training is supported.

#### 3.1. France: a centralized system where Ph.D. funding is based on government grants

Although the cost of investments in scientific and technical human capital is difficult to assess, a closer look at the sources of Ph.D. funding provides some useful indications. The main source of funding for

Table 3

Number of grants provided by the French Ministry of Research over the 1992–2000 period

Year	Discipline							
	Math., computer sciences	Physics and engineering	Geology, astron., astroph.	Chemistry	Life and natural sciences	Humanities	Social sciences	Total
1992	395 (11%)	1024 (27.5%)	221 (6%)	399 (11%)	810 (22%)	355 (9.5%)	489 (13%)	3693
1993	469 (12%)	1072 (26%)	235 (6%)	425 (10%)	861 (21%)	472 (12%)	525 (13%)	4059
1994	464 (11%)	1094 (26.5%)	235 (6%)	406 (10%)	835 (20%)	486 (12%)	599 (14.5%)	4119
1995	440 (11%)	1025 (27%)	211 (6%)	351 (9%)	747 (19%)	473 (12%)	615 (16%)	3862
1996	416 (12%)	945 (26%)	182 (5%)	335 (9%)	695 (19%)	457 (13%)	587 (16%)	3617
1997	423 (11.5%)	959 (26%)	186 (5%)	339 (9%)	724 (19.5%)	488 (13%)	597 (16%)	3716
1998	427 (11.5%)	920 (24.5%)	195 (5%)	350 (9%)	725 (19%)	529 (14%)	652 (17%)	3798
1999	414 (11%)	894 (24%)	192 (5%)	350 (9%)	761 (20%)	530 (14%)	654 (17%)	3795
2000	430 (11%)	891 (23%)	199 (5%)	356 (9%)	800 (21%)	564 (14%)	660 (17%)	3900

Sources: DGRT (1992, 1994, 1995, 2000, 2001). In brackets: proportion of the total number of grants for a given year.

French Ph.D. students is the Ministry of Research (MENRT): a third of the Ph.D.s completed each year have benefited from a MENRT grant (this figure stayed more or less constant over the 1990s). Table 3 shows that the total number of MENRT grants awarded each year stayed around an average of 3800 over the 1990s. Each grant is awarded for three years, which means that an average of 262.5 million euros was invested each year by the Ministry in the training of Ph.D. students, over the period. The distribution of these grants across scientific disciplines did not change much over the last decade: each year, the largest percentage of them (25%) went to physics and engineering, while life sciences attracted 20% of the total. The rest was divided among the five remaining groups of disciplines.

In addition, the Ministry funds some training programs for Ph.D. students in the private sector, such as the CIFRE (Industrial Convention of Training through Research). Overall, 47 million euros were dedicated in 1999 to specific frameworks involving firms in the training of Ph.D. Students. Other sources of funding include specific grants from public research organizations, other ministries, local authorities, etc. Private funding does exist, but involves only a minority of Ph.D. students (approximately 3% of each year's beginners).

### 3.2. The United States: a decentralized system based on excellence and research contracts

In the United States, graduate students rely on a shifting mix of support for doctoral studies, and few

benefit from the type of French national award to individual students. The left panel of Table 4 shows the distribution of various types of support for science and engineering doctoral students in 1995 (NSF, 2000). Fellowships are nationally competitive awards to individual students, and are by far the most infrequent source of support. Eight percent of students receive any award of this type, and only 4% consider it their primary support. In contrast to France, the majority of students obtain funding through their universities, payable via an extensive system of grants and contracts to their professors. The most common source of support is the research assistantship, which supports 70% of graduate students, supporting 42% of them exclusively. The majority of students provide at least some of the costs through their own resources, and through loans. More than half serve as teaching assistants to help finance their education. A recent National Science Board report (1996) concluded that it is not possible to link data on scientists with NSF support, and therefore issued no recommendations on funding mechanisms.

The individualistic tenor of doctoral funding in the United States masks an important reality: the majority of graduate student funding comes from the federal government. Fully 60% of academic training costs are borne by the federal government, which constitutes the primary source of support for 30% of graduate students (NSF, 1999). Whereas in France, the commitment is to the student, in the United States, the commitment is to the university and to the established researcher. Ninety-one percent of federal R&D

Table 4  
Types and sources of graduate support in the United States

Support mode	Students any support (%)	Students primary support (%)	Federal source	Percentage of academic R&D	Percentage of federal RA's
Fellowship	8	4	NIH	56	24
Traineeship	24	9	NSF	14	25
Research assistant	70	42	DoD	11	15
Teaching assistant	53	17	NASA	6	5
Loans	18	1	USDA	4	6
Own resources	58	18	All 5	91	75

Sources: NSF (1999, 2000).

Table 5  
Summary statistics

Variable	France		United States	
	Mean	Standard deviation	Mean	Standard deviation
Permanent academic position (censoring variable 1: yes, 0: censored)	0.41	0.49	0.38	0.48
Male	0.47	0.50	0.83	0.38
Research I undergraduate	Non-relevant		0.44	0.50
University-only training	0.74	0.44	Non-relevant	
Public Ph.D. funding	0.50	0.50	0.14	0.35
Industry Ph.D. funding	0.08	0.27	0.16	0.37
Publications during Ph.D	0.86	0.87	4.78	12.46
Postdoctoral position	0.27	0.44	0.36	0.48

support is financed by only five agencies: the National Institutes of Health, National Science Foundation, Department of Defense, NASA, and United States Department of Agriculture (see also the right panel of Table 5). Seventy-five percent of support for research assistants in the physical sciences comes from one of these five agencies (NSF, 1999). The focal recipient is not the student, however, but the university and the student's employing professor. A National Research Council report recently recommended that NIH doctoral funding programs targeted to individuals be increased (e.g., the National Research Service Award), with concomitant decreases in support for graduate research assistantships supported through grants to established researchers (NRC, 2000). Such recommendations, if implemented widely, would constitute a substantial shift in training policy, from training structures embedded in the laboratories of established researchers, to training structures developed to meet nationally-identified needs in the scientific and technical labor force.

#### 4. Entry into an academic career

The US system of graduate training developed primarily through the grants-making authority of federal science agencies. It is within this context of individual investigator-initiated, publicly funded, university-based, scientific research that the majority of US science training occurs. What is particularly odd about the system is that it occurs in an institutional context—the university—that is not the primary scientific employer, and the process of training and production is largely divorced from any intentional training or labor market policy. Furthermore, studies of academic careers tend not to evaluate the impact of the larger context of scientific funding, including the impact of industrial support and training.

In France, education and training are more explicitly understood as State responsibilities. Its tradition of doctoral education changed in 1984, when a system similar to the US model was fully instituted. From the perspective of comparative analysis, this policy

change helps to increase the comparability between the French and the American cases over the last decades. Ph.D. students acquire very specific, high-level scientific skills; during 3 or 4 formative years (although the rule is 3 years, the average Ph.D. duration in the 1990s was rather 3.5), they learn to behave and think as professional researchers. Thus, doctoral education can be seen as a very specific form of on-the-job training, acknowledged by a diploma.

If a French scientist fails to enter the academic sector (where tenure does exist from the lowest ranks on), he/she will have trouble finding a job in the private sector. As a consequence, a majority of young doctors occupy temporary positions (postdoctoral positions in foreign countries being first and foremost). These positions allow them to preserve their human and social capital, while waiting for a better academic opportunity. It is important to note that the vast majority of French Ph.D. students strongly desire to lead an academic career in France. Thus, those who choose to do a post-doc in a foreign country rarely settle down in this country; the majority returns to France, where they apply for stable academic positions. In the United States, the majority of postdoctoral positions are funded through grants to principal investigators, following the same model as doctoral training. The increasing emphasis on the postdoctoral position has been criticized for exploiting young researchers, and delaying entrance into the academic career (NAS, 2000; NRC, 1998; Tobias et al., 1995).

### 5. The scientific labor market “Promise”

Much has been written about the changing contract between new researchers and their principal employment target: the university (Tobias et al., 1995; National Research Council, 2000; Dany and Mangematin, 2004; Robin and Cahuzac, 2003). In effect, researchers are understandably concerned that academic careers are blocked to aspirants. However, the aspirations and aspirants themselves are the results of an institutional training context that glorifies the academic career at the expense of other scientific career paths. Those scientists who are able to obtain various sources of funding may be best positioned to capitalize on a variety of scientific opportunities. Mangematin (2000) found that French scientists trained at least in

part with industry funding were more likely to obtain permanent employment, while having a university grant increased the chance of temporary employment. Similarly, postdoctoral positions are important for obtaining academic employment, but only with respect to other temporary jobs (Robin and Cahuzac, 2003), and often at the cost of increasing the risk of temporary employment (Dany and Mangematin, 2004).

This study will put these findings in comparative context, using the French analytic tradition to evaluate dynamics in the US context. We hypothesize that scientists who are most flexible in their funding and training strategies will have the greatest early career success as measured by obtaining an open-ended contract (France), or tenure track job (US). Research of established scientists in American universities indicates that industry involvement actually improves academic grantsmanship (Gaughan and Bozeman, 2000). We therefore seek to examine the interplay of institutional forces during training and mobility early in the scientific career. We evaluate period effects, gender, educational prestige, doctoral funding, and early career experiences to estimate their impact on their transition to a permanent academic job in the critical three years following completion of the doctorate.

### 6. Data

Individuals rarely present themselves professionally as products of social processes, much less as being tossed about by the vagaries of larger economic, political, and social forces. Therefore, it becomes something of a challenge to cast individual-level survey and curriculum vita data in such a way as to understand basic policy processes. In our analysis, we use individual-level data to construct career trajectories, and conceptualize the institutional context and sources of funding as proxies for the impact of *de facto* science policy. Specifically, we examine how the nature of institutional affiliations and sources of support affect patterns of early academic career development of physical and life scientists.

The French data come from surveys administered to a sample of 400 French Ph.D. students in the life sciences who defended the dissertation between 1984 and 1994. The data include variables to assess sources of support, training and employment, and

career motivations (see Dany and Mangematin, 2004; Robin and Cahuzac, 2003). The American data come from the curriculum vita of 407 physical and life scientists who earned a Ph.D. between 1984 and 1997, a somewhat longer period than that covered in the French data set. This is because it is possible to observe entry into an academic position through 2000 in the US data. Whereas the French data come from self-reported surveys, the US data is based on coding of the academic curriculum vita (CV) of researchers in multidisciplinary, university-based science centers (see Dietz et al., 2000 for details about the sample and coding approach). The two data sets share the same time period, and a focus on natural scientists, but are not directly comparable in their methodology.

One of the challenges of this type of comparative analysis is determining how to create comparative measures. Our first challenge was to conceptualize the dependent variable, which is the hazard of entering into a permanent academic position within three years of completing the doctorate. In France, this is known as an Open-Ended Labor Contract (OEC), while in the United States, it is referred to as a tenure-track academic job. Next, we turned to characterizing educational experiences. Because Long et al. (1979) found that the prestige of the undergraduate degree had an independent impact on career success, we include such a measure. For the French students, University training refers to undergraduate training occurring in the most common educational institutions, while the reference category is comprised of the prestigious *Grandes Ecoles*. In the US, prestige is measured by whether the undergraduate attended a Carnegie Classification Research I University for the bachelor degree (Carnegie, 1987, 1994). The Research I universities are the predominant recipients of science funding in the US; therefore, training at one of them is an indirect indicator of policy impact.

We were also interested in evaluating how funding strategies affect later success on the academic job market. In the French context, public funding comes from MENRT grants; private funding, usually at the dissertation level, indicates industry collaboration with the student. In the United States, national funding refers to the recipients of individual-level fellowships and grants from the federal government (or, in a few cases, from state governments). Industry funding occurs through partnerships and employee exchanges.

The reference category is therefore research assistants, teaching assistants, and self-funded students. Finally, the publication productivity is measured by the number of publications the student authored as a graduate student (US), and the rate of publication as a graduate student (France). In the CV data, it was not possible to ascertain the length of doctoral training without making unwarranted assumptions for the majority of researchers.

We hypothesize that graduates of prestigious universities, and those who have obtained national funding for their work will be more likely to make the transition to a permanent academic position in the three years subsequent to earning the Ph.D. Those obtaining industry funding are less likely to do so, if only because of their greater intent to enter the private labor market. Furthermore, participation in temporary positions, including further postdoctoral study, will delay entrance into the career. Constructing comparative data for this indicator is difficult. In the French context, a postdoctoral position is by definition outside of France, whereas in the United States, it can take place anywhere (although the majority occurs within the US). In each sample, postdoctoral position is represented by a dummy variable, where the reference category is not beginning a postdoctoral position within three years.

Table 5 presents descriptive summary statistics of the two samples. Recall that we restricted the observation period to the first three years following the doctoral degree. The rate of transition to a permanent academic position is similar between the two nations: 41% of the French scientists, and 38% of the American scientists had entered a permanent academic position within three years. Note that both of these figures are substantially lower than the two-thirds of graduates who prefer an academic placement. There are stark gender differences between the two groups. Roughly half of the French scientists are male, while more than four-fifths of the American scientists are. In this paper, we introduce gender as a control only, to test for gender effects on entry into the career.

Roughly half of the US graduates attended a prestigious baccalaureate or Research I university prior to entering graduate school. Forty-four percent attended Research I universities, where they were likely to be exposed to the research enterprise, active researchers, and excellent science facilities that many other

American institutions of higher education are unable to afford. In France, the great majority (75%) of the Ph.D. graduates we followed had a university-only undergraduate training.

The funding profile of graduate students differs substantially between the two samples. In the French sample, half of students were supported by a public grant, higher than the national average. In the US, 14% of students were supported by competitive national grants and federally-funded traineeships, consistent with national trends. Twice as many students in the US had industry support during their graduate studies, but the percentage is only 16%. The majority of students in the US rely primarily on research assistantships, teaching assistantships, loans, and personal funds to complete training. The first two mechanisms are financed indirectly by various public and private institutions, but are at best oblique training policies at the national level. US students publish an average of almost five articles before completing the Ph.D., but the variable is skewed by some mature researchers who complete their Ph.D. in later life. In both countries, approximately one-third of graduates complete a postdoctoral position.

In summary, the samples indicate that similar proportions of Ph.D.s complete a postdoctoral position, and similar proportions obtain permanent academic employment within the first three years in France and the United States. However, the patterns of educational financing differ between the two societies. Generally, the French scientists enjoy a higher level of national support, while the American scientists rely more on individual financial efforts that are subsidized indirectly by government and industry. In the subsequent section, we use these indicators to evaluate predictors of success in entering into the academic career.

## 7. Findings

Our analysis uses a mixed proportional hazard model (Van den Berg, 2001) in a discrete-time framework (Allison, 1995; Jenkins, 1995) to estimate the effects of covariates on the hazard of entering a tenure-track/OEC academic position within three years of completing the Ph.D. This model is written, for any individual  $i$ :

$$\log h_i(t) = \alpha_t + X_i' \beta + u_i \quad (1)$$

where  $h_i(t)$  is the hazard that individual  $i$  experience the event at time  $t$ ,  $\alpha_t$  a time-specific fixed effect (a.k.a. “baseline hazard”),  $X_i$  a vector of explanatory variables with  $\beta$  its associated vector of parameters (to be estimated), and  $u_i$  a time-invariant, individual-specific random effect. The vector  $X_i$  contains only variables that are common to both the French and the US samples. The random effect captures unobserved heterogeneity, and controls, in particular, for those differences between the French and the American samples that are not accounted for in the vector of covariates. The model is estimated by conventional Maximum Likelihood.

Table 6 presents the results for the French (left panel) and US (right panel) samples. The time-specific effect  $\alpha_t$  is represented by the “Time” variable, which measures the time-dependence of the duration to the first tenure-track job/public OEC. Recall that individuals are followed for three years after the completion of their Ph.D. In the French sample, the relevant time unit is the quarter; therefore, the “Time” variable has 12 categories (one per quarter), category 1 being taken for reference. By contrast, the time unit in the US sample is a whole year, leading to a three categories “Time” variable, with the first year following completion being the reference category. For each level  $j$  of the “Time” variable, the coefficient is an estimate of  $\alpha_j - \alpha_1$ , i.e. the difference between the log-hazard of getting a tenure-track job in period  $j$  and the log-hazard of getting this job in period 1 (controlling for observed and unobserved individual characteristics). From this we derive an immediate interpretation of the constant term (first line of Table 6): it gives an estimate of  $\alpha_1$ , the log-hazard of getting a tenure-track position in quarter 1 for a French (or in the first year for an American) scientist with null values on all covariates.

In each sample, we examine the effect of similar vectors of covariates; the first covariate (QOC, standing for Quarter of Completion) controls for generational effect, i.e. the effect of the period at which the scientist completed doctoral training. Indeed, different generations of Ph.D. graduates face different political and economic conjunctures, and, generally speaking, different “states of the world”. In the French sample, the date of completion does not have an impact on the hazard of obtaining permanent academic employment within three years. That is, Ph.D.s who finished in 1984 are as likely to obtain permanent employment

Table 6  
Mixed proportional hazard models estimates: modeling transitions to first tenure-track job

Variable	France				USA			
	Coefficient	Standard deviation	Sign.	Exp (coefficient)	Coefficient	Standard deviation	Sign.	Exp (coefficient)
Constant	-2.21	0.62	0.000	0.11	-6.30	0.94	0.000	0.0002
QOC	-0.02	0.02	n.s.	0.98	0.51	0.08	0.000	1.67
Gender								
Male	0.26	0.29	n.s.	1.30	-2.20	0.53	0.000	0.11
Female								
Undergraduate University	-0.80	0.35	0.023	0.45				
Training (France) Other								
Undergraduate Research I					1.19	0.40	0.003	3.29
Training (US) Other								
Funding								
Public/national	0.25	0.31	n.s.	1.28	-1.21	0.51	0.016	0.30
Private/industry	-0.65	0.59	n.s.	0.52	0.85	0.55	n.s.	2.34
Other/none								
Publications	-0.02	0.16	n.s.	0.98	-0.03	0.03	n.s.	0.97
Postdoctoral position								
Yes	-1.25	0.49	0.011	0.29	0.06	0.52	n.s.	1.06
No								
Time								
2	-1.92	0.56	0.001	0.15	0.28	0.39	n.s.	1.32
3	-0.51	0.40	n.s.	0.60	0.97	0.46	0.034	2.64
4	-1.03	0.52	0.047	0.36				
5	0.12	0.48	n.s.	1.12				
6	-0.16	0.57	n.s.	0.85				
7	-0.47	0.65	n.s.	0.62				
8	0.10	0.64	n.s.	1.11				
9	0.34	0.67	n.s.	1.41				
10	0.07	0.72	n.s.	1.07				
11	-0.13	0.77	n.s.	0.88				
12	1.06	0.73	n.s.	2.89				
1 (reference)								
Rho	0.80	0.09	0.018	Non-relevant	0.96	0.01	0.000	Non-relevant
Log-likelihood			-613.04				-378.39	

n.s.: non-significant.  $H_0: \beta = 0$  rejected at the 1% level of significance (LR test). Rho measures the contribution of the individual-specific effect to the total variance; it would not make sense here to give its exponential. The French sample allows consideration of quarterly transitions, while the US sample is based on years. Therefore, the time variable refers to quarters in the French sample; it refers to years in the US sample.

as those who finished in 1997. By contrast, the year in which the US scientists finished does have a substantial impact. Those obtaining more recent Ph.D.s are much more likely to have obtained a permanent

academic position than those who finished during the 1980s. This is very likely a period effect resulting from massive increases in funding through the National Institutes of Health during the 1990s, which resulted in

additional faculty positions in the biomedical sciences. Furthermore, the period also witnessed the foundation and expansion of NSF-supported Science and Engineering Research Centers as university-based institutions for academic employment.

The French and US academic labor markets also differ for men and women. In France, being male is not an advantage in obtaining an academic position. However, in the US men are less likely than women to obtain a permanent academic position within three years. From a policy point of view, one would expect to see no gender difference. However, the US finding rests on the fact that over four-fifths of the scientists are male. The women who make it into the survivors group must be competitive indeed. In addition, US universities have made some progress in recent years in using affirmative action policies to recruit female scientists. See [Sonnert and Holton \(1996\)](#) for an introduction to gender stratification in science.

In the United States, obtaining an undergraduate degree at one of the 125 Research I universities is highly predictive of entry into an academic career. Such graduates are more likely to become academics than their peers who attend other types of educational institutions (which constitute the vast majority of the thousands of institutions of higher education in the United States). In France, attendance at one of the Grand Ecoles has a similar effect on the transition to stable public employment: individuals with a university-only type of training are 55% less likely to experience this event than those with a more selective type of undergraduate training.

In France, funding mix does not determine entry into the academic position, contrary to our hypothesis. Even more surprising, being awarded a prestigious national fellowship in the United States actually reduces the odds of obtaining an academic position within 3 years. In neither country does industry funding add or detract from the likelihood of making the transition. Considering the sums of money devoted to training, it is interesting to find that the mode of financing does not appear to have an impact on entry into the academic career in France. Furthermore, the student's publication productivity as a graduate student has no impact, although it should be noted that most Ph.D.s had published at least once, which may constitute a threshold effect.

The effect of our last covariate, postdoctoral positions, differs between the US and France. In the American sample, completing a postdoctoral position neither helped nor hindered entry into an academic career. In the French sample, spending time in this temporary status just after completion tended to delay the transition to a permanent academic position. This is an important result, since it may reveal two distinct modes of scientific workforce management in France and in the USA.

In the USA, mobility is an expected component of early careers, and does not hinder subsequent careers: young Ph.D. scientists are seen as assets, their mobility being essential to the transfer of scientific knowledge between research institutions. As [Almeida and Kogut \(1999\)](#) state for engineers, Ph.D. graduates embody high-level scientific knowledge, and their mobility corresponds to the circulation of this knowledge, which fertilizes R&D activities. In France, "post-docs" are grudgingly accepted by young Ph.D. graduates, since they delay access to a permanent job. In the French system, young researchers who quickly receive permanent positions are seen as the brightest. In the French academic system, little consideration is given to the process of knowledge transfer, and Ph.D. graduates have few incentives to get actively involved in it.

Finally, in the second-to-last line of [Table 6](#) is featured an estimate of the term "Rho". This term measures the contribution of the individual-specific effect  $u_i$  to the total variance. In the French sample, Rho is significantly different from zero. This simply means that, in a model without a random effect  $u_i$  (which absorbs unobserved heterogeneity), the estimated coefficients would be biased. The same conclusion is reached in the American sample, lending support to our decision to use a model controlling for random effects.

## 8. Conclusions and policy implications

In the first half of the paper, we explored the contours of the French and American scientific labor forces, focusing in particular on the cohorts of doctoral level scientists in the last two decades of the 20th century. In each nation, substantial numbers of scientists are produced each year, the majority of whom are supported directly or indirectly through

governmental support. Although the national training policies tend to be implicit rather than explicit, they nevertheless affect thousands of individuals and hundreds of millions of dollars each year. We sought to operationalize variables that would allow us to examine their effects on the career development of young scientists. Specifically, we examined the role of elite institutions, sources of financial support, and predoctoral productivity on the transition to the first permanent academic position. We found significant differences between the French and the US academic systems.

During the undergraduate experience of would-be scientists, attendance at a prestigious Research I institution (in the United States) or at a Grand Ecole (in France) greatly increases the likelihood of obtaining permanent employment at the end of doctoral training. Since the majority obtain the Ph.D. from Research I-type programs, it is unlikely to be a difference in professional scientific training as such. One reader suggests that undergraduates at these prestigious institutions are more likely to see research behavior being modeled at an earlier career age. A darker view is that stratification occurs early in the career, as established scientists recreate status hierarchies based on the prestige of the undergraduate diploma. Since these institutions receive enormous governmental resources in both countries, this is a finding worthy of further investigation and consideration.

Sources of graduate training operate differently in France and the United States. In France, industrial or public support does not advantage an academic aspirant over those who have supported themselves. It is encouraging that an individual is equally likely to enter the academic labor force irrespective of the source of his or her doctoral support. The finding in the US sample that prestigious national support has a negative impact on the first professional academic transition has serious policy implications. These grants to doctoral trainees free them from dependence on established researchers; the student is unlikely to be exploited, but this result suggests that the student may not develop the scientific and technical human capital necessary for succeeding on the academic job market. Recently, the National Research Council argued for increased reliance on fellowship awards, and decreasing reliance on research assistantships funded through grants (NRC, 2000). Therefore, it is impor-

tant that this result be studied further before whole graduate training financing systems are changed in the US.

In the US context, we found scant evidence for postdoctoral positions erecting barriers to entrance to the academic career. By contrast, evidence does support the hypothesis that postdoctoral and temporary positions are serving as barriers to the French academic labor market. If we keep in mind that Ph.D. graduates embody scientific knowledge, this result underlines two very different ways of managing the transfer of knowledge. In the US, knowledge management is closely related to human resources management: mobility in early careers is encouraged, since it allows knowledge circulation and renewal. In France, knowledge transfer and human resources management in R&D are treated as two distinct topics, which may explain why R&D seems sometimes more sluggish in France than in the US.

However, due to its integration in the European Research Area, France may have to change its policy towards researchers' mobility in the near future. European authorities now consider that the lack of long-term jobs for mobile researchers constitutes an important waste of human capital and resources. Thus, initiatives to promote the appointment of mobile junior Ph.D. scientists to longer term positions may be implemented in the coming years (MCFA, 2002). This should take place in the larger context of a European market for scientists, which is still in the building process. The removal of obstacles (be they legal, financial, etc.) to the free mobility of Ph.D. scientists inside Europe is a major objective of the Sixth European Framework Program for R&D (Commission of the European Communities, 2002).

Ultimately, greater attention should be paid to the number of new researchers being produced, and to the number of available positions in a variety of sectors. There is beginning to be greater attention paid to the shifting loci of scientific employment for doctoral recipients (NRC, 1998). In the future, these types of dynamics may be better modeled as competing risks for a variety of possible career outcomes. Such an analysis is already possible with our French data. However, in the US case, the nature of the "academic" CV is such that it is difficult if not impossible to identify other types of career paths from it. Such data are essential if

we are to study fully the range of opportunities available to early career French and US scientists.

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