

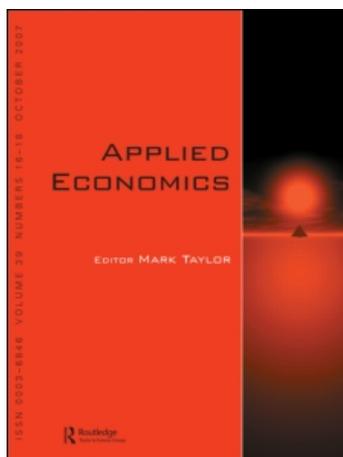
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### Do female researchers face a glass ceiling in France? A hazard model of promotions

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# Do female researchers face a glass ceiling in France? A hazard model of promotions

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The present article examines whether French female researchers face a glass ceiling, an invisible barrier to promotion. Using an original database from the National Institute for Agricultural Research (INRA), we estimate duration models for promotions. The methodology used allows us to take into account censored observations and unobserved heterogeneity. Our results show a significant gender effect that does not contradict the glass-ceiling hypothesis. In addition, factors that boost promotion seem to be radically different according to gender and we present evidence that promotion strategies are different for males and females.

## I. Introduction

Whatever the profession (Altonji and Blank, 1999, for an overview; Spurr and Sueyoshi, 1994; Joy, 1998; Albrecht *et al.*, 2003, for studies of specific jobs), the literature provides a large amount of evidence for gender-related differences in earnings and promotion. Focusing on promotion, females seem to be under-represented in senior positions, suggesting that women face a *glass ceiling* that limits their promotion. This glass ceiling is a result of gender discrimination, which like other forms of discrimination, is socially unacceptable. However, the glass-ceiling phenomenon may also generate negative incentives for women (because they are less likely to be promoted, they could, quite rationally, invest less in their work), depriving the economy of competencies that could be used more efficiently. These social and economic costs have provided a driving factor for research into the existence and effects of a glass ceiling.

In academia, the question of whether or not a glass ceiling exists is all the more interesting because this sector is attracting increasing numbers of women; therefore negative incentives may generate higher costs than in other sectors. Nevertheless, Benjamin (1999) notes that academia does not seem to have

escaped the glass-ceiling phenomenon. The ETAN (European Technology Assessment Network) Report (2000) states that, in all Organization for Economic Cooperation and Development (OECD) countries, the proportion of females decreases further up the rank ladder. On average, there are three times as many women in ‘assistant’ positions (30.5% are women) and twice as many women in ‘lecturer’ positions (20.5% are women) than in ‘full professor’ positions (10.4%).

These statistics seem to be consistent with the presence of a glass ceiling but observed gender difference among academics could be caused by gender disparities in the different areas of academia. For example, Schneider (1998) notes that a greater proportion of women are involved in teaching activities, which could explain why women tend to publish less and why they are less likely to be promoted.

In order to establish the existence of a glass ceiling in academia, other factors that affect careers must be taken into account. Econometric analyses are thus required in order to obtain *ceteris paribus* evaluations of the situation facing women.

However, microeconomic studies are relatively scarce and most of them have focused on wages.

Studies carried out using Mincer equations generally find significant wage gaps between men and women, even after controlling for individual characteristics, publication scores and department characteristics, etc. Using American data from the Survey of Doctorate Recipients (SDR), Ginther and Hayes (1999) calculated the gender gap in Human Sciences to be 9% in favour of men. According to Ward (2001a), women in Scottish academia earn 26% less than their male counterparts. Although these studies do not refute the glass-ceiling hypothesis, they show that the phenomenon may not be clear cut. First, the gender wage gap has decreased since the 1970s (Ransom and Megdal, 1993). Second, estimated wage gaps are mainly caused by gender differences in observable heterogeneity. For example, by applying Oaxaca (1973) decomposition, Ward (2001a) showed that only 3 percentage points of the estimated 26% difference in wages can be attributed to discrimination. Ginther and Hayes (2003) confirmed this result and demonstrated that gender wage gaps are mostly due to gender rank differentials. This suggests that wages are directly related to rank.

More recently, research has focused on the promotion process. Ginther and Hayes (2003) estimated promotion probabilities using univariate probit models. They concluded that women in the Human Sciences are significantly less likely to be promoted to tenured positions, *ceteris paribus*: the estimated gap is about 8%. Similarly, Mixon and Trevino (2005) reported discrimination against female economists in the US South. Applying the Oaxaca decomposition to a logit model of promotion, they found that the promotion probability is 12.2 percentage points lower for females and that 7.6 of these 12.2 points cannot be explained by differences in productivity, and are therefore due to discrimination.

The glass ceiling can still be seen when the dynamic process of promotion is taken into account. Using a random-effects probit model, McDowell *et al.* (2001) concluded that the 'average woman' is 36% less likely to be promoted to the 'assistant professor' rank and 9% less likely to be promoted to the 'full professor' rank. Similarly, Kahn (1993) found that the risk ratio for female economists obtaining tenure is about two-thirds of the male ratio. Ginther and Hayes (2003) found similar results in the Humanities, where the estimated gender gap in promotion rates is large; women are 25% less likely to be promoted, *ceteris paribus*.

The empirical literature does not refute the hypothesis that women are less likely to gain access to senior positions, which suggests that a glass ceiling does exist for academics, whatever discipline they

are in. However, existing results are based on data from America or the United Kingdom, countries that have very similar academic systems, and it could be argued that gender gaps result from certain characteristics of these systems that are unfair to females. Therefore, it would be interesting to test the glass-ceiling hypothesis in another type of academic system. In this respect, the French system provides an interesting alternative, as French academia has a number of specific features that set it apart from the American or British systems (see Euwals and Ward (2000) and Ginther (2001) for detailed descriptions of these two academic systems).

Firstly, in contrast to other countries, the French academic sector has two branches: universities and national research laboratories. Each branch is independent and has its own working rules. For example, researchers working in the national research institutes have no teaching duties, unlike those working in universities.

Secondly, in USA or the United Kingdom, academic careers are dominated by tenure rules. After completing a PhD, a young researcher is hired as an assistant professor on a fixed-term contract. Tenured status (as a full professor) is not awarded until later in an academic's career and this status is not offered to all academics. Promotion criteria include scientific achievements, such as the number of papers published and their quality. French academia is organized quite differently. A key difference that applies to all French institutions (universities and national research laboratories) and all disciplines is that lifetime contracts are awarded soon after hiring. Recruitment is based on the quality of the research carried out during the PhD, but researchers become tenured civil servants after only 12 months' probation and this occurs almost automatically. Civil servant status implies a life-long job and, for a given rank, a fixed wage scale. There are two main and equivalent ranks in French academia: assistant professor and full professor in the university system and researcher and senior researcher in the national research laboratories. Salaries for each rank and status are fixed by a national collective agreement and are the same for all universities and research laboratories. Academics at the same level in the hierarchy all receive the same salary.

In France, the objective of seeking promotion is not to get tenure (since this is automatic) but to earn a higher salary and to obtain greater responsibilities (such as being a PhD supervisor or managing a team of researchers). As in other countries, promotion to the senior rank depends on scientific achievements, which are evaluated by promotion committees.

Another difference is that all disciplines in French academia are organized according to this general framework and they all follow the same general hiring and career rules. As stressed in the stylized facts, an examination of the promotion process reveals large differences between the genders. This suggests that, despite the differences between the French and American/British academic sectors, French female researchers are also under-represented in the senior ranks and therefore a glass-ceiling exists.

The aim of this article is to test whether a study of promotion paths supports this hypothesis. As in the literature, we will take into account both observed heterogeneity, such as individual attributes and scientific achievements, which can explain promotion gaps and unobserved heterogeneity, which are often neglected. As career paths in French academia can only be described by changes in rank, the gender effect is evaluated according to the probability of becoming a senior researcher.

In order to carry out this research, we had to overcome a major obstacle, there is no generally available dataset on academic careers in France. In Section II, we explain how we constructed a panel dataset for researchers' careers. This dataset allowed us to examine the career paths of a group of biologists working at the National Institute for Agricultural Research (INRA), one of France's national research institutes. By focusing on life scientists at a single institute, we were able to produce homogenous data that could be used to test the glass-ceiling hypothesis, thereby providing the first study of this phenomenon in France.

## II. The Data

As there is no official dataset describing the career paths of researchers in France, we constructed one, using information from the administrative files of INRA. INRA was founded in 1946 to develop scientific knowledge in the fields of agriculture, food and the environment. In terms of publications in these fields, INRA ranked second in the world. In 2002, INRA had 260 research departments and employed about 1800 researchers, 37% of whom were female. As in other national research institutes, INRA's researchers are divided into two ranks: researchers and senior researchers. In 2002, 35% of INRA's researchers held the senior researcher rank.

**Table 1. Proportion of researchers in senior positions**

	Men (%)	Women (%)
INRA	51	15
Universities	43	18
Public research institutes	45	25

*Source:* Livre Blanc (2002).

Also like other national research institutes, there is almost gender parity amongst researchers but women are under-represented amongst senior researchers, only 5.5% of researchers are female senior researchers. Furthermore, the situation for female researchers at INRA is worse than at other public research institutes or universities. Table 1 shows that the proportion of senior researchers among women is 10 percentage points lower at INRA than at other public institutes.

Most of the scientists recruited by INRA are hired as researchers, with promotion to the senior researcher rank, if justified, being awarded later in their careers.<sup>1</sup> Our research focused on this particular promotion path. Promotion to the senior researcher rank mainly occurs through a formal, internal, competitive process that begins with the publication of available positions on INRA's website or in journals. In order to apply, applicants must fulfil certain eligibility criteria, including possession of a PhD and at least 8 years of experience (at INRA or another research institution). Applicants must submit their CV together with outlines of their previous research activities (mostly carried out while at INRA) and of their future projects. Applications are examined by promotion committees composed of researchers from INRA and other institutes or universities, who draw up a short list of the most suitable, eligible candidates. These short-listed candidates are then interviewed, ranked and eventually promoted.

This description of the promotion process at INRA highlights the fact that applications for senior posts are mostly endogenous. Researchers' decisions to apply for senior researcher posts are usually based on seniority, the quality of their scientific work and the number of positions available. The probability of applying must therefore be examined. Unfortunately, our administrative dataset only provides information about promotion decisions and not about applications. Furthermore, no details are provided about decisions concerning the eligibility of applicants or the number of positions available. In order to

<sup>1</sup>In recent years, a small number of scientists have been recruited directly as senior researchers. As this type of career path does not constitute promotion within INRA, it was not analysed in this study.

minimize bias, the empirical part of our study focused on researchers, who have sufficient experience to be promoted. Nevertheless, the potential endogeneity bias could not be fully controlled in our study and our results must therefore be interpreted with caution.

Despite this limitation, the dataset allowed us to observe individuals' entire careers at INRA and the length of time, people stay at the researcher rank before being promoted to senior researcher. Section III of the present article investigates whether gender has a significant effect on this duration, which is sometimes right-censored.

Of the researchers at INRA, we decided to focus on the 583 researchers in biology, INRA's main discipline. In order to describe their career paths, we combined two administrative datasets. The first lists the length of time spent in each rank; the second contains the activity reports each researcher supplies for his or her annual evaluation. These data are collected from the time a researcher begins work at INRA, until the date that person is promoted to a senior researcher position, or to the end of 2002, if he or she is still at the researcher grade at this time. From the 583 researchers observed, we selected individuals for further study on the basis of two criteria: they should have more than 8 years experience at INRA and they had to have been recruited during a year in which both male and female researchers were recruited. These two criteria allowed us to focus on researchers, who fulfilled the eligibility criteria for promotion, and to compare cohorts containing both male and female subjects. Our final sample contained 357 researchers.

These 357 researchers were then divided into a number of cohorts. Following the example of Ransom and Megdal (1993), we created a dummy variable, COH1 (hired by INRA before 1980), in order to capture cohort effects, which could, for instance, be produced by changes in the promotion process. In fact, in recent year's recruitment and promotion procedures in the French academic sector as a whole seem to have become more competitive than they were in the early 1980s. We also had information about several individual attributes. For example, we know which researchers graduated from the 'Grandes Ecoles', France's top universities (TOP\_UNIV), which are considered to attract the best students. We also know if a researcher can

supervise PhD students, a role for which a specific diploma (HDR)<sup>2</sup> is required. These two variables, TOP\_UNIV and HDR are likely to indicate a higher human capital and play a role in the promotion process.

Our data also contain information on a researcher's mobility. This mobility could be due to undertaking a postdoctoral fellowship (POSTDOC), a visiting professorship or a sabbatical abroad after being hired at INRA (MOB). Mobility is often viewed as an opportunity for acquiring new competencies and for networking. Networks built up within the scientific community provide greater opportunities for cooperation and can increase scientific achievement; therefore mobility can increase the chances of promotion.

In contrast to other datasets described in the literature, our sample contained information on all aspects of a researcher's work, including each researcher's publication record. These publication records were combined with data from the Science Citation Index, which provides an impact factor (based on the journal quality index)<sup>3</sup> for each publication, in order to construct a publishing score (articles published weighted by journal quality) that reflects publishing productivity (PUB\_SCORE). Like McDowell *et al.* (2001), we preferred this mixed indicator to a simple quantitative measure of publications, which does not take into account the impact or reputation of the scientific work. In addition, we also had information about each researcher's degree of involvement in scientific projects (as a participant, NPROJECT or a coordinator, NPROJ\_C) and in administrative activities. These activities include managing a research team or a department (BOSS) or networking activities, such as belonging to a professional body (NETW) or membership of strategic, recruitment or promotion committees (COMMIT). All these attributes provided us with more detailed information on a researcher's scientific achievements and reputation, which are pillars of the promotion criteria.

However, the richness of our dataset may have a negative counterpart; scientific work might be endogenous. For example, the most highly motivated researchers could be the ones who do the most research and contribute most to the literature and who are the most likely to be promoted. But, valid instruments are needed to identify these processes.

<sup>2</sup>In order to obtain an 'HDR' diploma, also known as a 'Habilitation', a candidate must prepare a written document outlining his or her contribution to science. As for a PhD, this document must then be defended in front of a jury.

<sup>3</sup>The impact factor is complete for all publications from the early 1980s onwards, but it may be more imprecise for earlier publications. This must then be taken into account in the econometric results and comments. We therefore introduced a cross variable between COH1 and PUB\_SCORE, in order to treat the potential collinearity.

**Table 2. Descriptive statistics**

Variables	Full sample	Females	Senior researchers	Female researchers	Male researchers	Female senior researchers	Male senior researchers
PROM: being promoted to senior position	40.9%	22.0%					
FEM: being female	35.6%		19.2%				
COH1: hired before 1980	31.9%	12.6%	64.4%	4.0%	14.3%	42.9%	69.5%
HDR: having the PhD supervisor diploma	14.3%	15.7%	17.1%	6.1%	17.9%	50.0%	9.3%
TOP_UNIV: graduated from a top university	27.7%	18.9%	45.2%	17.2%	14.3%	25.0%	50.0%
POSTDOC: having held a postdoctoral fellowship	10.4%	14.2%	3.4%	17.2%	13.4%	3.6%	3.4%
MOB: mobility since entry at INRA	17.4%	13.4%	18.5%	14.1%	18.8%	10.7%	20.3%
PUB_SCORE: publication productivity	22.66	23.62	15.65	19.93	34.22	36.67	10.66
NPROJECT: number of projects	1.39	1.35	1.51	1.08	1.52	2.32	1.31
NPROJ_C: number of projects coordinated	0.53	0.45	0.64	0.35	0.54	0.79	0.60
BOSS: managing team or laboratory	15.1%	7.1%	30.8%	3.0%	5.4%	21.4%	33.1%
COMMIT: participating in strategic committees	62.5%	69.3%	58.9%	67.7%	62.5%	75.0%	55.1%
NETW: having networking activities	13.4%	8.7%	17.8%	6.1%	14.3%	17.9%	17.8%
Number of observations	327	127	146	99	112	28	118

Unfortunately, our dataset is not informative enough to allow us to test both the determinants of scientific achievement and the length of service before promotion.

In addition, our administrative dataset does not provide information on personal characteristics, such as marital status and number of children, or on the activities of each research department. Previous studies have found these variables have a significant effect on the promotion process; therefore neglecting them could generate an omitted-variable bias. This point will be discussed in the following section.

Table 2 provides descriptive statistics for the whole sample and for sub-samples determined according to gender and/or grade. Among the 327 individuals in the sample, 35.6% were female and 40.9% were senior researchers. However, only 19.2% of women held senior positions. These figures are very similar to the general situation at INRA (i.e. for all disciplines); women are under-represented in the highest ranks.

For some staff promotion duration (defined in months) is right-censored; however, the median time taken to achieve promotion is 136 months, with the median time for males being 8 months less than the median time for females. In order to take

into account censored observations, we estimated simple Kaplan–Meier survival rates on yearly intervals (Fig. 1).

Nonparametric hazard rates highlight the fact that, throughout a person's career, the hazard rate for females is always lower than the hazard rate for males; the cumulative hazard rate is about 77% for males but only 49.2% for females.

However, this difference could be caused by gender differences in other variables that affect promotion (Table 2). First, large differences exist between individuals who have been promoted to the senior researcher rank and those still at the researcher rank. In general, staff promoted to the senior researcher rank joined INRA at an earlier date, 64.4% were hired before 1980 (only 32% in the full sample). More surprisingly, senior researchers had lower publishing scores (at the hiring date) and were more involved in administrative activities. Second, female senior researchers had specific characteristics. In general, they had been hired more recently than male senior researchers, they had higher publishing scores than the males and they carried out fewer administrative activities.

As the general profiles of senior researchers and of female staff were very different, it was necessary to carry out an econometric analysis of the dataset in

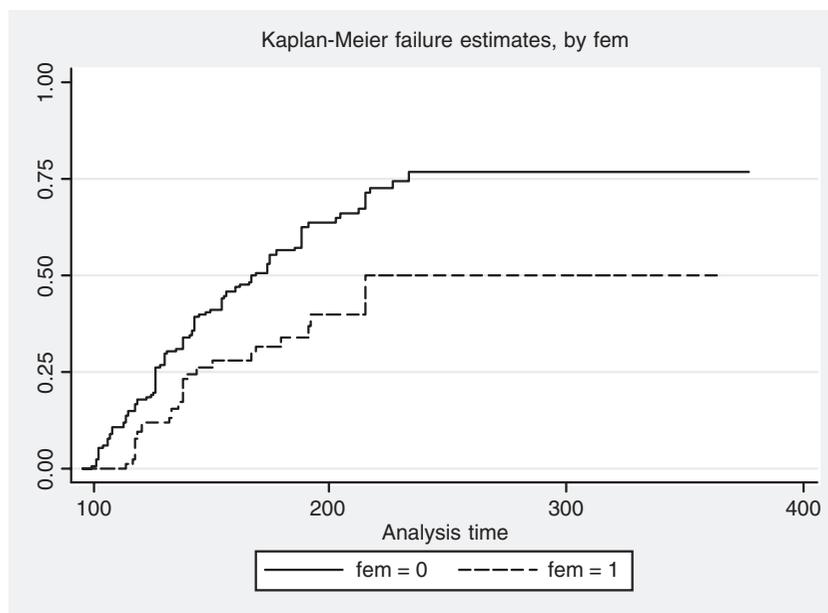


Fig. 1. Kaplan–Meier hazard rates

order to evaluate the gender gap in promotion rates at INRA.

### III. Modelling the Determinants of Promotion Duration

The descriptive evidence clearly indicates that women are under-represented in senior researcher positions at INRA. Our aim was to test whether this gender differential remains after controlling for observed and unobserved heterogeneity. Instead of estimating the probability of being promoted (as in Mixon and Trevino, 2005), we focused on the hazard rate, denoted  $\lambda_i(t)$ . This allowed us to take into account both the dynamic dimension of the promotion process and potential unobserved heterogeneity terms, which can bias estimations. This hazard rate can be expressed as follows:

$$\lambda_i(t) = \frac{p(t \leq T < t + dt / T \geq t)}{p(T \geq t)} = \frac{f(t)}{S(t)} \quad (1)$$

where  $T$  is the length of time (in months) spent at the researcher grade,  $f(t)$  is the density distribution and  $S(t)$  the survival function.

Using the model of McDowell *et al.* (2001),  $\lambda$  can be viewed as the probability at time  $t$  that an individual's productivity exceeds the department

productivity threshold (probability of being promoted), given that this productivity is lower than the threshold at least until  $t$  (probability of being not promoted until  $t$ ). As both individual productivity and the productivity norm for the department are latent variables,  $\lambda$  denotes the probability of becoming a senior researcher, given that no promotion occurs before  $t$ .

Estimations of this hazard rate were performed using duration models (Lancaster, 1990), which allowed us to take into account the fact that 67.6% of the individuals studied were still at the researcher grade at the sampling date; that is to say, more than two-thirds of the observed durations were right-censored. We estimated a parametric model (with an accelerated failure-time form) that allowed us to control for both observed and unobserved explanatory factors. Kaplan–Meier estimates have shown that hazard rates are nonmonotonic, and therefore a log-logistic distribution<sup>4</sup> was applied.

In our parametric specification, the hazard rate,  $\lambda_i$ , was assumed to depend on three factors: a vector of observable characteristics  $X_i$ , an individual specific effect  $v_i$  and an error term  $\varepsilon_i$ .

The  $X$  vector included gender, mobility characteristics, publishing score, investment in projects and administrative activities. The  $v_i$  term was added to capture individual unobserved heterogeneity. Using panel models, McDowell *et al.* (2001) pointed out

<sup>4</sup>Various specifications for distributions of durations (log-normal, weibull, etc.) were tested. The results were not affected by the specifications chosen.

Table 3. The determinants of promotion duration

Explanatory factors	Model 1		Model 2		Model 3	
	Full sample		Male		Female	
	Time ratios	<i>t</i> -ratios	Time ratios	<i>t</i> -ratios	Time ratios	<i>t</i> -ratios
Constant	1.02	2.01**	0.99	1.04 <sup>ns</sup>	1.01	0.73 <sup>ns</sup>
FEM: being female	1.12	2.67***	–	–	–	–
COH1: hired before 1980	0.89	–3.11***	0.71	–3.96***	0.95	–3.01***
TOP_UNIV: graduated from a top university	0.93	–1.87*	0.92	–2.15*	0.98	–1.65 <sup>ns</sup>
HDR: having the PhD supervisor diploma	0.90	–2.12**	0.98	–1.21 <sup>ns</sup>	0.92	–2.28**
POSTDOC: having held a postdoctoral fellowship	1.01	–1.18 <sup>ns</sup>	1.02	0.97 <sup>ns</sup>	0.96	–2.19**
MOB: mobility since entry at INRA	0.95	–2.09**	0.94	–2.08**	0.98	–1.14 <sup>ns</sup>
NPROJECT: number of projects	0.87	–2.12**	0.88	–1.93*	0.95	–1.98**
NPROJ_C: number of projects coordinated	0.84	–3.73***	0.76	–3.82***	0.98	–1.54 <sup>ns</sup>
PUB_SCORE: publication productivity	0.97	–1.53 <sup>ns</sup>	0.99	–1.54 <sup>ns</sup>	0.56	–2.31***
BOSS: managing team or laboratory	0.81	–6.26***	0.63	–4.02***	1.01	1.06 <sup>ns</sup>
NETW: having networking activities	0.97	–1.42 <sup>ns</sup>	0.98	–1.07 <sup>ns</sup>	0.96	–1.38 <sup>ns</sup>
COMMIT: participating to strategic committees	0.98	–0.61 <sup>ns</sup>	0.97	–1.04 <sup>ns</sup>	1.03	0.97 <sup>ns</sup>
COH1*PUB_SCORE	1.07	2.15**	0.94	2.61***	1.04	1.13***
$\sigma$	0.31	17.04***	0.23	7.41***	0.18	5.59***
$\theta$	1.53	3.88***	1.18	4.33***	1.79	4.06***
Log-likelihood	–223.52		–218.91		–201.65	
Observations	327		230		127	

Notes: Estimated coefficients have been rounded to two decimal places. Robust *t*-ratios (using heteroscedastic-consistent errors from White's (1982) procedure) are reported.

\*\*\*Statistically significant at 1% level, \*\*significant at 5% level and \*significant at 10% level, ns: not significant.

that neglecting unobserved heterogeneity could cause endogeneity bias and lead to spurious results. Several attributes, such as number of children, marital status and the characteristics of the research department, were missing from the administrative dataset used for our study. As noted earlier, studies have shown that these variables have significant effects; therefore their omission increases the risk of endogeneity bias. We were able to overcome this difficulty by modelling  $v_i$ , a term with a gamma distribution ( $\Gamma(v_i)$ ), unit mean and variance  $\theta$ .

The survival function, denoted  $S(t)$ , can then be written as follows:

$$S(t_i) = \int_{v_i} S(t_i|v_i)f(v_i)dv_i \quad (2)$$

with

$$S\left(\frac{t_i}{v_i}\right) = \Phi[-\sigma \ln(\lambda_i t_i)] \quad (3)$$

where  $\lambda_i = e^{-\beta' X_i}$ ,  $t_i$  is the promotion duration and  $\Phi$  is the cumulative distribution function for the standard normal distribution and

$$f(v_i) = \frac{k^k}{\Gamma(k)} e^{-k v_i} v_i^{k-1}, \quad \text{where } k = \frac{1}{\theta} \quad (4)$$

From this general specification, three different models were estimated (Table 3). Model 1 estimated the effect of gender on promotion duration for the whole sample, including both the observed and the unobserved heterogeneity. Models 2 and 3 gave results by gender, in order to test whether or not the effects of explanatory variables on promotion duration are gender dependent.

For each estimated model, robust *t*-statistics were calculated (White, 1982). The results are presented in Table 4. They reflect the *ceteris paribus* effects of each covariate on the promotion duration. Time ratios are also given. A time ratio, which is lower (higher) than one indicates that the characteristic decreases (increases) promotion duration. Time ratios provide interesting information because, as well as giving the sign of the effect of a variable, they enable its quantitative effect to be evaluated by indicating how much the promotion duration increases or decreases for a given explanatory variable. For example, if the time ratio of a covariate  $X$  is 1.21, the promotion duration for researchers with the  $X$  attribute will be 1.21 times higher than the duration for researchers lacking this characteristic, *ceteris paribus*.

Model 1 shows the importance of correcting for unobserved heterogeneity, in that it provides an estimate of the  $\theta$  parameter, which is significantly different from zero. Thus, the model must take into

account unobserved factors, as neglecting the  $v_i$  terms would introduce bias into the estimated effects, including the impact of gender.

Model 1 also allows us to examine the effect of gender. The model shows that an ‘average woman’, i.e. a female researcher with the same characteristics as a male researcher, has to wait longer for promotion. Promotion durations for females are 1.12 times longer than for their male counterparts. Gender is one of the variables with the highest effect on promotion duration.

This result supports the glass-ceiling hypothesis; however, a more detailed picture can be revealed by examining estimated hazard rates by gender (Fig. 2). These estimated hazard rates were evaluated for female and male average characteristics.

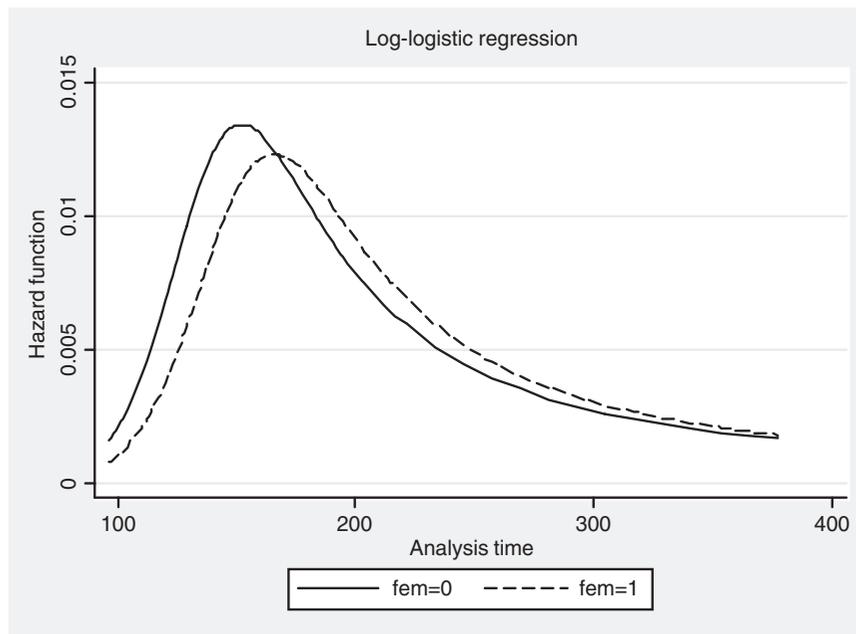
Although women had lower predicted hazard rates, on an average, than men, we observed that this

overall result does not apply throughout women’s careers. In the first half of their careers, women had lower predicted hazard rates but, after 180 months, their hazard rates were slightly higher. This result was obtained after controlling for observed and unobserved factors. It cannot be explained by omitted individual attributes; however, a statistical explanation is possible. As females are promoted later than males (see below), after 15 years employment females with the competencies needed for promotion are more numerous than males. Thus, at this stage in their careers, we observe more females at risk than males. Finally, the promotion rate for females is higher than that for men. However, the higher hazard rates for females in the second half of their careers do not compensate for the lower hazard rates in the first half. This conclusion is strengthened by the fact that the female hazard rate peaks later and at a lower value than the male hazard rate. Females are less likely to be promoted and when they are promoted it tends to be later in their careers. Hence, although there are differences in the career patterns of female and male researchers, a glass ceiling still seems to exist. This is consistent with the findings on promotions in the USA reported by Kahn (1995), McDowell *et al.* (2001) and Ginther and Hayes (2003). Although there are major differences between the French academic system and the American and British systems, female researchers at INRA still find it more difficult to gain promotion than their male counterparts.

**Table 4. Predicted and simulated median promotion durations**

	Predicted from model 1		Simulated from models 3 and 4 <sup>a</sup>	
	Male	Female	Male	Female
Median duration	192.18	225.26	225.04	236.23

*Note:* <sup>a</sup>These simulations were obtained using the mean values of  $X$  for females (males) but the estimated coefficients for males (females).



**Fig. 2. Predicted hazard rates by gender (model 1)**

As well as gender, promotion durations also seem to be affected by recruitment date. Our results show that older cohorts were promoted more quickly than more recent cohorts. For example, the promotion duration for personnel recruited before 1980 was 0.89 times that of more recent cohorts. This could be due to a less competitive recruitment environment before 1980, to a greater availability of promotions and/or to fewer researchers being eligible for promotion. Among scientific achievements, which are the main criteria for promotion, the most influential variable is BOSS. Managing a team reduces promotion durations by a factor of 0.81. Developing and coordinating projects also shorten promotion durations, but the publication score (PUB\_SCORE) has no significant effect. Hence, it seems that the promotion criteria do not all have the same effect on promotion duration and that investing in managerial activities is more profitable than carrying out research in terms of achieving promotion.

Models 2 and 3 provide evidence of interaction between gender and other variables, suggesting that gender affects promotion duration both directly and indirectly through its effect on the explanatory factors of promotion. A different career path can be identified for each gender. For females, promotion is accelerated by higher scientific production in terms of PUB\_SCORE or projects (NPROJECT), whereas for males, promotion is accelerated by managerial achievements (managing a research team (BOSS) or coordinating projects (NPROJ\_C)). This result indicates the coexistence of two strategies for promotion: the first based on scientific achievements, publications or participation in projects, and the second based on managerial responsibilities. Our data suggests that the choice of strategy depends strongly on gender. Further, work is needed to confirm the existence of such gender-based specialization.

Estimates of promotion duration by gender highlight that unobserved heterogeneity only affects the promotion duration of females (Model 3). This could be explained by the fact that our dataset does not include attributes such as marital status, number of children and career interruptions due to motherhood. Recent studies have shown that these factors do affect women's careers.

Our promotion duration models allowed us to make a number of predictions and simulations.

The results of Model 1 were used to estimate the median promotion durations for males and females. When censored observations and unobserved and observed covariates were taken into

account, we found that females have to wait about 2.75 years longer for promotion than males. However, simulations carried out with female attributes evaluated equally to male attributes (using  $\hat{\beta}_{\text{male}}$ ), and inversely, with male attributes evaluated equally to female attributes (using models 2 and 3), gave longer promotion durations than those predicted by Model 1. However, the gender gap in these simulated promotion durations was still less than 1 year in favour of men. In fact, in the hypothetical case of male attributes being evaluated equally to female attributes, the simulated promotion duration for males would be 2.8 years longer than the predicted duration. For females, the simulated promotion duration was only 1 year longer. This result seems to show that promotion duration is not only affected by gender differences in the covariates but also by the way these covariates are evaluated.

#### IV. Conclusion

Although there is substantial evidence for a glass ceiling in French academia, no previous attempts had been made to prove or disprove its existence. Therefore, the present study is the first to investigate whether the promotion durations of French researchers are dependent on gender. As there was no available dataset on researchers' careers, we began by constructing a database that would allow us to analyse complete career paths and research activities of French researchers. Focusing on biologists at the INRA, we examined promotion durations for elevation to the senior researcher rank. Our duration models show that females have significantly lower hazard rates, in particular in the first half of their careers, than their male counterparts. This result was obtained after controlling for both observed and unobserved heterogeneity. We also found that the explanatory factors for promotion durations are very different for the two genders. This seems to suggest a sort of gender specialization, with greater scientific achievements providing the fastest route to promotion for female researchers and greater managerial responsibilities being the best way of ensuring promotion for male researchers.

Our analysis does not refute the hypothesis that the promotion of women at INRA is limited by a glass ceiling; however, further research is needed to investigate the effects of the differences in the promotion strategies adopted by male and female researchers.

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