Ph.D. Students' Career Outcomes in the Short and in the Long-Run, by Gender

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Abstract

We examine differences in the employment careers of men and women Ph.D.s from two major European universities. We find that women are more likely than men to be employed in public administration. They are also more likely to remain in academia than work in industry. These differences persist after accounting for Ph.D. curricula characteristics. Gender gaps are reduced for women with large research outputs and for those who conducted applied research. Women are less likely than men to pursue postdoc training in highly ranked universities and publish fewer articles. These differences largely explain the gender gap in promotion to professorship.

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In the US, women in science have been found to be less productive (Kelchtermans and Veugelers, 2013), to earn less, and to receive promotions later than men (Ginther and Kahn, 2009). Women with postdoc training are more likely than men to find positions in business, government, and non-profit sectors than in academia (Blau and Kahn, 2000). Little is known, however, about the career patterns of European women in science. With the exception of Mairesse and Pezzoni's (2015) analysis of the promotion patterns of French academic women, there is a limited understanding of European women's employment choices after they receive Ph.D.s. This is an important gap if one considers that Europe is the second-largest producer of scientific articles, after the US. In general, in the US and Europe, it is still not clear how the characteristics of Ph.D. curricula and subsequent postdoc training affect gender differences in career attainments.

To fill these gaps, we use detailed information about Ph.D.s in science and engineering from two major European universities, one located in Sweden and the other in Switzerland. The organization of these universities is very similar to that of other European institutes of technology[3]. We have information about Ph.D.s' employment outcomes after graduation and whether they pursued careers in academia (including research centers), industry, or public administration (including schools and teaching colleges)[4].

We find that women are more likely than men to be employed in administration. They are also more likely to work in academia than industry. These differences persist after accounting for their publication outputs during their Ph.D., their involvement in applied projects, and their supervisors' characteristics. However, the gender gap in the probability of being employed in

[3] See, for instance, the Polytechnic University of Turin, the Swiss Federal Institute of Technology in Zurich, the Eindhoven University of Technology, and the Karlsruhe Institute of Technology.
[4] In what follows, we will use the term "administration" to refer to "public administration".

academia relative to administration disappears when we compare men and women with large publication outputs. The gender gap in the probability of being employed in industry is reduced for women who participate in applied projects during their Ph.D.. When the sample of Ph.D.s who pursued postdoc training is considered, we find that women are less likely than men to be employed in highly ranked universities, even after controlling for their research outputs. Finally, we find gender differences in Ph.D.s' promotion to professorship. These differences are largely explained by the quality and publication output of the Ph.D.s' postdoc training.

I. Ph.D.s' Career Choices

To build our sample, we obtained lists of Ph.D.s who graduated from the Swedish Chalmers University of Technology (Chalmers) and the Swiss Federal Institute of Technology in Lausanne (EPFL) during 1999-2009. These institutions share a number of characteristics: they are leading research institutions in their own countries, they focus on science and engineering, and they have extensive collaborations with the industrial sector. Moreover, their supervisors directly select Ph.D. applicants at both universities and Ph.D. duration is fixed to four years.

From the initial population of Ph.D.s (2061 at EPFL and 1290 at Chalmers), we only retained those for whom we had complete information about their employment. This information was gathered through extensive internet searches. The final sample comprises 2345 students: 1462 from EPFL and 883 from Chalmers. Women represent 21 percent of the total (20 percent of the EPFL sample and 23 percent of the Chalmers sample). Of the final sample, 1185 students accepted postdoc positions in either universities or research centers after their graduation. Of those, 87 became professors, 930 were employed in the industrial sector, and 143 were employed in administration. The majority of Ph.D.s (1562) took positions in their graduation country.

Descriptive statistics not presented here show that the career patterns of EPFL and Chalmers Ph.D.s are very similar.

Our initial research questions are: i) Are there gender differences in employment choices of Ph.D.s? and ii) Can such gender differences be explained by observable factors, with a specific focus on the students' Ph.D. curricula characteristics? To address these questions, we estimate multinomial logit models, which consider the following employment outcomes after graduation: academia, industry, or administration. We estimate the following equation:

$$\Pr(y_i=j|\mathbf{x}_i)=\frac{\exp(\mathbf{x}_i\boldsymbol{\beta}_j)}{\sum_{j=1}^{M}\exp(\mathbf{x}_i\boldsymbol{\beta}_j)} \quad (1)$$

where $j=1,2,3,\ldots,k,\ldots,M$; $\Pr(y_i=j|\mathbf{x}_i)$ is the probability that Ph.D. i attains employment category j, given $\mathbf{x}_i$; and $\mathbf{x}_i$ is a vector of covariates. In addition to a Ph.D.'s gender, $\mathbf{x}_i$ includes demographic variables of age and nationality. We distinguish between foreign students from EU-15 countries and the remaining foreign students.[5] The mean graduation age is 30 years for both men and women. The percentage of foreign Ph.D.s among women is 51, while among men it is 42. We also include an indicator for whether a student had worked prior to starting his or her Ph.D.. Fourteen percent of men and 8 percent of women had worked prior to starting their Ph.D.. As part of a Ph.D.'s curriculum, we control for publication count (including conference proceedings) and involvement in applied projects during the Ph.D.. This last measure is an indicator that equals one if a student was granted a patent, had published with industry partners during his or her Ph.D., or was employed by a company during the Ph.D.. The mean publication count is 7 for men and 6 for women. Eighteen percent of men and 14 percent of women were involved in applied project.

[5] PhDs from outside the EU-15 face considerable limitations in their ability to work in Sweden or Switzerland.

We include supervisor characteristics because these are likely to be correlated with a Ph.D.'s curriculum. Thus, we control for a supervisor's publication count in the five years prior to Ph.D. *i*'s enrollment, whether he or she was granted patents, was involved in European projects with companies,[6] and had worked in industry prior to becoming a professor[7]. We add graduation-year fixed effects, university-research field fixed effects (engineering, life sciences, chemistry, physics, and mathematics), and measures for labor market conditions at graduation. The latter measures encompass the size of a Ph.D.'s graduation cohort (distinguishing between basic science and engineering), and an indicator that increases in value with higher country GDP growth. We control for the availability of positions in R&D-intensive companies with the number of patent applications filed by Sweden and Switzerland at the European Patent Office in the year in which a Ph.D. graduated. We proxy the availability of postdoctoral positions at a Ph.D.'s university of graduation with the number of professors affiliated with EPFL and Chalmers in the same field as Ph.D. *i*. We also control for the availability of postdoc positions in the US, as many Ph.D.s pursue postdoc training in the US. This measure is defined as the difference between the number of postdocs hired by US universities in a given year and the number of US Ph.D.s who graduated in that year in the same field as Ph.D. *i*.

Results are reported in Table 1. Coefficients are relative risk ratios. Ratios greater than one indicate that an increase in the regressor leads to a higher probability that an outcome *j* will occur rather than outcome *k*, with the opposite being true for ratios less than one. Standard errors are clustered around supervisors. Employment in academia is the base outcome. Our strategy

[6] At both Chalmers and EPFL, European projects are an important component of the total collaborations that professors establish with industrial partners.

[7] One possibility is that men and women match with supervisors who have distinct characteristics. Thus, supervisors' controls may capture unobserved Ph.D.s' characteristics that are correlated with gender. However, in probit models not reported here, we show that supervisor characteristics are not significantly correlated with our gender indicator.

consists of gradually introducing the aforementioned controls and assessing whether and how these controls affect gender differences in Ph.D.s' employment attainments. Columns I and IV include the gender indicator, Ph.D.s' demographic and predetermined characteristics, measures for labor market conditions at graduation, and fixed effects. As shown, women are significantly less likely than men to be employed in industry and more likely to work in administration.

These preliminary results lead us to the question of whether gender differences in employment outcomes could be explained by characteristics of the students' Ph.D. curricula. It could be that women are more likely to be employed in administration because they are less productive or are associated with supervisors who are less productive. To examine this question, we add a Ph.D.'s and his or her supervisor's publication outputs to the baseline regressions. Results in columns II and V show that a Ph.D.'s publication count is an important predictor for the probability that the student will get a job in academia. However, even upon controlling for research productivity, women remain more likely than men to work in administration than academia.

Women could be less likely to work in industry because they are less involved in applied projects. We explore this avenue by controlling, in columns III and VI, for whether a Ph.D. participated in applied projects during their Ph.D. studies. We also include indicators for whether a supervisor was granted patents, collaborated with firms during her appointment, and worked in industry prior to becoming a professor. The indicator describing a Ph.D.'s involvement in applied projects and the one capturing whether his or her supervisor had worked in industry are both significant predictors of a Ph.D.'s probability of being employed in industry. Relative to the specifications including a Ph.D.'s and his or her supervisor's publications, the gender coefficient increases, regardless of whether the base outcome is employment in academia or administration. This result points to a reduced gender gap that, however, remains significant.

[Insert Table 1 Here]

Next, we examine how the gender gap in employment attainments varies when we compare men and women with similar research profiles. We also take a closer look at the Ph.D.s' postdoc positions and distinguish between those in highly ranked and those in low ranked universities. The goal is to assess whether there exists a gender gap in the likelihood of pursuing postdoc positions in highly ranked universities. The results in Table 2 are derived from estimating a series of logit models. Coefficients are odds ratios and standard errors are clustered around supervisors.

We initially found that women are more likely than men to work in administration relative to academia. In Panel A, we assess whether this gender gap persists among those Ph.D.s with a large number of publications. We limit the sample to Ph.D.s who worked in academia or in administration after graduation. For ease of interpretation, we substitute publication count with an indicator for whether the Ph.D. had published more than his or her field's average. We then interact this indicator with the gender variable. A t-test on the difference of the interaction coefficient and the large-publication-output coefficient reveals that the difference is not significant, with a p-value of 0.72. This indicates a reduction in the gender gap of Ph.D.s with similar levels of productivity.

In Panel B, we explore whether there are gender differences in the probability of working in industry relative to academia or administration among Ph.D.s involved in applied projects. We thus interact the gender variable with the indicator for whether Ph.D.s pursued applied projects. T-tests on the difference of regression coefficients show that women involved in applied projects are as likely as men not involved in such projects to work in industry. However, their likelihood of working in industry is lower than that of men who participated in applied projects.

In Panel C, we restrict the sample to Ph.D.s who pursued postdoc careers and estimate their probability of being employed in highly ranked universities. Universities are denoted as highly ranked if they are in the last quartile for the number of articles published in the same field as Ph.D. *i*. At both Chalmers and EPFL, Ph.D.s who intend to pursue careers in academia are strongly encouraged to take postdoc positions abroad. Thus, we consider postdocs in Sweden or Switzerland to be low ranked.[8] According to our classification, 22 percent of postdocs took positions in highly ranked universities. Women are found to be less likely than men to take these positions, even when we control for their research outputs and those of their supervisors.

[Insert Table 2 Here]

II. Promotion to Professorship

The next research question we examine is whether there are gender differences in promotion to professorship, with a specific focus on the characteristics of Ph.D.s' postdoc training. For this purpose, we restrict the sample to Ph.D.s who pursued a postdoc. We then estimate competing-risks models that account for the fact that a Ph.D. is at risk of transitioning to multiple different occupations, in addition to being promoted to professor. The hazard of becoming a professor, $h_j(t|\mathbf{x_i})$, is modeled as follows:

$$h_j(t|\mathbf{x_i}) = h_{j,0}(t)\exp(\mathbf{x_i}\boldsymbol{\beta_x}) \quad (2)$$

where $h_{k,0}(t)$ is the baseline hazard and $\mathbf{x_i}$ is a vector that contains the same covariates as in equation (1) plus labor market conditions at time *t* and characteristics of a Ph.D.'s postdoc training[9]. For the sake of brevity, we do not show the regression coefficients, but directly plot the cumulative incidence functions in Figure 1. These functions give the proportion of Ph.D.s at time

[8] The results are robust even under different classification criteria not discussed in this paper.
[9] In the case of GDP growth at time *t*, we compute the average between the GDP growth of the country in which PhD *i* was working in *t-1* and the GDP growth of the country in which PhD *i* was working in at time *t*.

t who have become professors but could have transitioned into any other occupation. Panel A excludes from the covariates in equation (2) the characteristics of a Ph.D.'s postdoc training. The difference between men (dashed line) and women (straight line) in promotion to professorship is large and significant. Panel B includes in $\mathbf{x}_i$ the number of articles that a Ph.D. published during her postdoc and an indicator for whether the Ph.D. pursued her postdoc in a highly ranked institution. The gender gap in promotion to professorship is no longer significant.

[Insert Figure 1 Here]

III. Conclusions

Our results show that gender gaps exist in the employment outcomes for Ph.D.s in Europe. This is an interesting finding in light of the organizational differences, including gender policies, between European and US universities. In general, our findings have important implications for university administrators and policy makers. For instance, women Ph.D.s could be oriented to applied research projects to improve their odds of working in industry. In parallel, governments could set incentives for firms to hire women Ph.D.s that participate in those projects. Moreover, grants aimed at encouraging women's mobility could help to close the gender gap in promotion to professorship.

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Table 1: Multinomial logit results for Ph.D.s' employment attainments, after graduation (*We use employment in academia as base outcome*)

PANEL A	Industry		
	I	II	III
Female	0.690***	0.609***	0.616***
	(0.086)	(0.076)	(0.077)
Ph.D. demographic and predetermined characteristics			
EU-15 nationality	0.808*	0.841	0.881
	(0.091)	(0.097)	(0.103)
Non-EU-15 nationality	0.511***	0.528***	0.571***
	(0.074)	(0.078)	(0.087)
Age	0.987	0.961**	0.945***
	(0.019)	(0.018)	(0.019)
Worked prior to Ph.D.	2.614***	2.625***	2.188***
	(0.394)	(0.398)	(0.337)
Ph.D. publication output			
# of publications during Ph.D.		0.534***	0.500***
		(0.036)	(0.034)
Ph.D. involvement in applied projects			
Involved in applied projects during Ph.D.			3.127***
			(0.418)
Supervisor publication output			
Pre-sample # of publications		1.104	1.092
		(0.067)	(0.068)
Supervisor involvement in applied projects			
Had patents granted			1.014
			(0.129)
Prior working experience in industry			1.460***
			(0.188)
Involved in EU projects with industrial partners			0.843
			(0.108)

PANEL B	Public Administration		
	IV	V	VI
Female	1.662***	1.464**	1.456*
	(0.322)	(0.284)	(0.283)
Ph.D. demographic and predetermined characteristics			
EU-15 nationality	0.609**	0.643*	0.661*
	(0.140)	(0.150)	(0.155)
Non-EU-15 nationality	0.357***	0.365***	0.382***
	(0.106)	(0.110)	(0.115)
Age	1.103***	1.067**	1.057*
	(0.034)	(0.034)	(0.034)
Worked prior to Ph.D.	0.971	0.962	0.903
	(0.297)	(0.302)	(0.290)
Ph.D. publication output			
# of publications during Ph.D.		0.522***	0.509***
		(0.061)	(0.060)
Ph.D. involvement in applied projects			
Involved in applied projects during Ph.D.			1.776**
			(0.501)
Supervisor publication output			
Pre-sample # of publications		0.979	0.994
		(0.107)	(0.113)
Supervisor involvement in applied projects			
Had patents granted			0.772
			(0.182)
Prior working experience in industry			0.813
			(0.185)
Involved in EU projects with industrial partners			1.223
			(0.264)

Notes: Coefficients are relative risk ratios. N=2,345. Robust standard errors are clustered around supervisors. Employment conditions at graduation, graduation-year and university-field fixed effects are included.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 1 percent level.

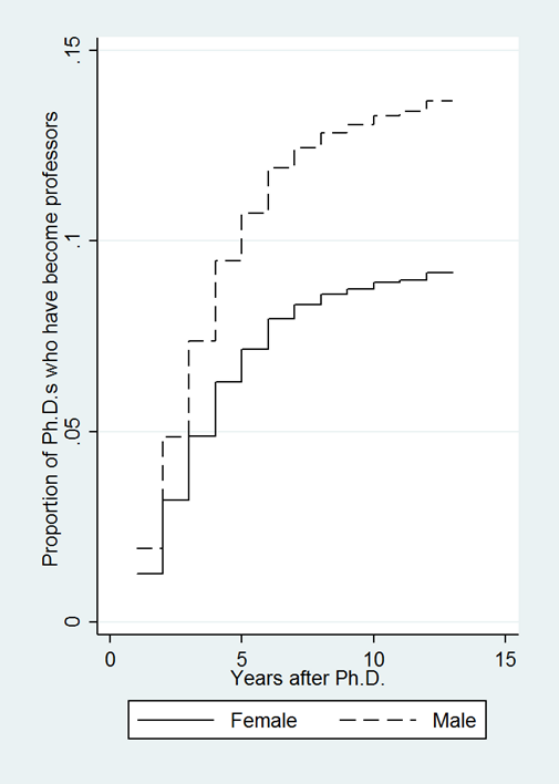
Table 2: Logit results for Ph.D.s' employment attainments, after graduation

	Odds ratio
PANEL A: Probability of being employed in administration (*Ph.D.s who worked either in academia or administration after graduation*)	
Female	1.423
	(0.320)
Large publication output	0.390***
	(0.103)
Large publication output * Female	1.130
	(0.575)
PANEL B: Probability of being employed in industry (*Entire sample*)	
Female	0.587***
	(0.082)
Ph.D. involvement in applied projects	1.016
	(0.331)
Ph.D. involvement in applied projects*Female	2.931***
	(0.431)
PANEL C : Probability of pursuing postdoc trainings in highly ranked universities outside of the graduation country (*Ph.D.s who pursued a postdoc career*)	
Female	0.660**
	(0.138)

Robust standard errors are clustered around supervisors. We include employment conditions at graduation, Ph.D. characteristics, supervisor characteristics, graduation-year, and university-field fixed effects.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 1 percent level.

Figure 1: Cumulative incidence functions for promotion to professorship

PANEL A: No controls for postdoc training



PANEL B: With controls for postdoc training