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A revealed preference analysis of PhD students' choices over employment outcomes

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ABSTRACT

We develop a revealed preference approach to elicit science and engineering PhDs' preferences over employment outcomes, exploiting cohort size variations. Depending on whether pecuniary and non-pecuniary rewards are sticky or not, increments in the PhDs' cohort size decrease either the availability of their ideal employment categories or the related compensations. In both cases, the PhDs' preferred employment categories are revealed to be the ones that are relatively less chosen when the PhDs' cohort is large and relatively more so when it is small. Examining two major European universities, we find that PhDs equally value employment in highly-ranked universities and R&D-intensive companies. Moreover, these employment categories are preferred to low-ranked universities, non-R&D-intensive firms, and public administration. There is preference heterogeneity across PhDs depending on their research field.

1. Introduction

The organization of PhD programs around the world has been subject to increased policy debate. At issue is whether universities produce too many PhDs, given the limited availability of permanent academic positions (Stephan, 2012a).[1] One key step for assessing the optimal size of a PhD program is understanding the PhDs' preferences with regard to career outcomes. Whether or not PhD programs are oversized may depend on the students' evaluations of careers outside of academia, which can offset the reduced availability of tenure-track positions. More generally, it also depends on whether PhDs' preferences are consistent with the training they received during their PhD program. In fact, the large amount of resources that governments spend on PhD programs is based on the assumption that PhDs will work in positions that facilitate knowledge transfer and provide returns to those governments. Our study contributes to this ongoing debate by developing a novel revealed preference approach to elicit PhDs' preferences over employment choices while exploiting cohort size variations. We implement this approach using a fine-grained dataset of science and engineering PhDs who graduated from two major European universities during 1999–2009.

PhDs form preferences for certain employment categories based on the history of pecuniary and non-pecuniary compensation offers. Once they are in the job market, they begin by applying for their most preferred employment categories and then consider applying for the least preferred ones. If compensations are sticky, which is the most compelling assumption given our empirical context, variations in the PhDs' cohort size act as a revealing preference mechanism by affecting the probability that PhDs are offered their ideal employment. *Ceteris paribus*, when the PhDs' cohort size increases, applications for their ideal categories rise, reducing the probability that the PhDs are employed in these categories relative to the other categories available in their choice set. If compensations are regulated by labor market conditions (Oyer, 2006; Stephan and Ma, 2005), variations in the PhDs' cohort size impact the attractiveness of their ideal employment categories by affecting the associated expected compensations. *Ceteris paribus*, when the PhDs' cohort size increases, applications for their ideal categories rise, reducing the associated expected compensation and making other categories relatively more attractive. If students

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[1] See also Conti and Liu, 2015a,b(forthcoming), Stephan (2012b), Cyranoski et al. (2011), Stephan (2007), and Freeman et al. (2001).

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are forward-looking and anticipate the consequences of PhD cohort size increases, they would increase their applications for their less preferred employment categories when graduating from a large cohort. In all cases, the PhDs' ideal categories are the ones that are less frequently observed when the students' cohort is large and more frequently so when the cohort size is small.

We apply our revealed preference method to a sample of 2,345 students who obtained their PhD degree from the Swedish Chalmers University of Technology (Chalmers) and the Swiss Federal Institute of Technology in Lausanne (EPFL). These universities have a number of characteristics in common: they are leading universities in their own countries, they specialize in science and engineering disciplines, and they are actively involved with the industrial sector. Using multiple sources, we collected detailed information on the PhDs' careers. The richness of our data allows us to go beyond the dichotomous distinction between employment in universities and that in the industrial sector (Stephan, 1996). For instance, we rank universities and research centers according to their publications.[2] We also observe positions in public administration, schools, and teaching colleges.[3] Within industry we distinguish between employment in R&D-intensive companies, non-R&D-intensive companies, and startups. This fine-grained categorization is an important contribution to the existing literature. Undoubtedly, within industry and also within academia, there is an ample spectrum of employment possibilities which differ in a number of significant respects (Sauermann and Stephan, 2013).

We analyze a set of exhaustive and mutually exclusive employment categories among which PhDs can choose, just after graduation. We estimate a series of multinomial logit models which relate the PhDs' employment outcomes to their cohort size and other controls. We have an unusually large set of background variables that allow us to account for factors that may be correlated with the PhDs' cohort size and with their employment attainments. For instance, we include measures for labor demand conditions at graduation, given that they may influence a student's selection into a given PhD cohort. Moreover, we have fine-grained measures of students' research skills and orientation, as well as information about their pre-enrollment working experience. We also control for supervisors' characteristics, including their publication or patent output.

We find that when cohort size is large, PhDs are less likely to be employed in R&D-intensive companies or in highly-ranked universities, as opposed to working in low-ranked universities, non-R&D-intensive companies, startups, and the administration. Thus, we deduce that R&D-intensive companies and highly-ranked universities are the most preferred employment options. This preference ordering is consistent with the transitivity axiom of preference relations, given that positions in R&D-intensive companies and in highly-ranked universities are preferred to the same employment alternatives. Moreover, and again in line with the transitivity axiom, employment in low-ranked universities is not preferred to positions in non-R&D-intensive companies, startups, and the administration. These results are robust across a number of specifications in which, amongst others, we deal with the possible endogeneity of cohort size.

These findings challenge the traditional wisdom that PhDs are unconditionally inclined towards the academic realm and less prone to compromise with the industry norms (Dasgupta and David, 1994). Rather, they illustrate that the research quality of universities and the closeness of companies to the academic *modus operandi* play a fundamental role in the students' choice between industry and academia. Interestingly, students appear to be indifferent between employment in low-ranked universities and non-R&D-intensive firms, suggesting that the non-pecuniary benefits offered by the former offset the higher wages typically provided by the latter.

When we analyze PhDs in engineering and in basic sciences separately, we find some preference heterogeneity. Specifically, we find that the attractiveness of employment in highly-ranked universities and in R&D-intensive firms declines more steeply with the cohort size for PhDs in engineering compared to those in basic sciences. This result suggests that the opportunity costs of choosing these employment alternatives increase faster, following a cohort expansion, for engineering students when compared to students in basic sciences.

Our results provide a fundamental contribution to the literature on PhDs' preferences over employment outcomes. Sauermann and Roach (2012) surveyed a sample of US PhDs in basic sciences asking the respondents to rate a number of employment options. They find that academic research careers are highly regarded by their survey participants and supervisors play an important role by encouraging these career choices. Compared to their stated preference approach, our methodology provides three key advantages. First, it does not suffer from well-known shortcomings intrinsic to inferring information about PhDs' preferences from survey answers. To cite a few drawbacks, survey responses are sensitive to the way questions are formulated (Beshears et al., 2008). Respondents also have a tendency to express views that they think are in line with the survey organizers' opinions (Zizzo, 2010) or with socially acceptable positions.[4] Another source of bias comes from the fact that the respondents are aware their preferences are being investigated.[5] Finally, survey participants may simply not have the incentive to truthfully express their preference ordering (Bertrand and Mullainathan, 2001). The second advantage of our approach is that, due to the richness of our background variables, the revealed preference ordering we obtain is not confounded by factors such as individuals' gender, nationality, abilities, and supervisors' characteristics. These aspects have been found to play an important role in shaping PhDs' preferences (Fox and Stephan, 2001). The last advantage is that, in contrast to Sauermann and Roach (2012), we examine a more detailed employment choice set that distinguishes between R&D and non-R&D-intensive companies and between highly-ranked and low-ranked research institutions. In related papers, Stern (2004) and Sauermann and Roach (2014) evaluate the determinants of the stated wage premium that senior scientists or PhDs require to be employed in non-research-intensive firms, as opposed to research-intensive ones. Moreover, Agarwal and Ohyama (2013) and Pellens et al. (2013) examine the optimal sorting of PhDs into labor market outcomes according to their stated preferences. They find that students with *ex-ante* preferences for non-pecuniary rewards are more likely to sort into academia. Our work is the first to consider labor market conditions as a lever to infer PhDs' preferences

The remainder of the paper is as follows. Section 2 presents a conceptual framework to guide our empirical analysis. Section 3 describes the empirical context. Section 4 discusses the empirical method. Section 5 presents the results and Section 6 the robustness checks. Section 7 explores preference heterogeneity between students in basic sciences and engineering. Section 8 concludes.

[2] Unless otherwise specified, we shall include in the "university" category universities as well as research centers.

[3] We shall include in the "public administration" category occupations in schools and teaching colleges. In what follows, we will use the term "administration" to refer to public administration.

[4] This phenomenon is known as "experimenter demand effect".

[5] This phenomenon is known as "observer effect".