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Commercial research at universities and career choices of science and engineering doctoral students

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Abstract

We investigate the relationship between the levels of industry collaboration and entrepreneurial activities at universities and the employment choices of their science and engineering doctoral students. Using data from 176 U.S. universities over the period 1996-2005, we document that more interaction with industry at a university is typically associated with more of the university's doctoral students choosing industry employment. We also document a positive relationship between universities' licenses and startups and their graduates' post-doctoral study choices.

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1. Introduction

The public funding cuts following the 2007-2009 economic downturn have proliferated the significance of revenue-generating research for most universities in the U.S. and Europe. Partnerships with industry and entrepreneurial activities at a university facilitate connections, opportunities, and perceptions that may influence its doctoral students' career choices. The consequences for the distribution of human capital between academia and industry remain to be explored. Commercial research experience and associated connections with potential employers in the industry may make the transition to private sector easier. Both commercial research and entrepreneurial activities increase students' knowledge about the practices and the rewards of the private sector, but they also allow the PhDs to exploit the commercializable products of their research without leaving the university. Also, the funds generated through all these activities may allow the universities to create more research faculty/staff positions. The net effect is an empirical question, which we examine in this paper.

Research has investigated various issues related to the academic/scientific labor market[1] and to university research funding.[2] The existing empirical papers on the determinants of doctoral students' career choices are, however, "either based on a few university cases or on evaluation of particular programs" (Thune, 2009). Fox and Stephan (2001) and Roach and Sauermann (2010) study the career preferences of young scientists in the U.S., with primary focus on scientists' personal characteristics, using data from two small-scale surveys. The current paper focuses on the role of *the university* on its graduates' career choices, using data from 176 universities in the U.S. over the period 1996-2005. We document a significant link between the industry shares in universities' funding (and a weaker link between their entrepreneurial activities) and employment choices of their science and engineering doctoral students upon graduation.

2. Data, Empirical Analysis, and Findings

The data on research funding and licensing activities of universities come from the Statistics Analysis for Tech Transfer (STATT) database, collected by the Association of University Technology Managers (AUTM). University-level data on career outcomes of doctoral students come from the Survey of Earned Doctorates (SED), conducted by National Opinion Research Center (NORC) for the National Science Foundation (NSF). The SED groups the *finalized* post-graduation plans of respondents under four categories: post-doctoral training, academic employment, private sector employment, and "other," which mainly consists of career choices with the government and non-profit organizations. Using the SED, we can match 176 of the 182 AUTM surveyed institutions.[3]

[1] See Ehrenberg (1992) and Stephan (1996) for reviews of the earlier literature, and Stephan (2012) for more recent references.
[2] Goolsbee (1998), Walsten (2000), and Stephan (2012) include discussions on various effects of different sources of research funding.
[3] Because of privacy policies related to personal information, the NORC suppressed the data cells with less than 5 graduates. Furthermore, some variables are missing for Ph.D. recipients whose career choices have traditionally been limited such as those in independent medical institutions, which rarely produce graduates

Our *proxy* for the share of commercial research at university i in year t is the ratio of research support by industry to the federal research support at that university in that year ($IndFedRatio_{it}$).[4] We employ three metrics for different phases of academic entrepreneurship: The number of new patent applications ($NewPatents_{it}$) represents the earliest stage of entrepreneurship, and is a proxy for the academic strength of the institutions and the degree of potentially applied research undertaken. The cumulative number of licenses and options that are active in year t ($Licenses_{it}$) measures both the efficacy of university technology transfer system and the stock of ongoing relationship with the industry. Given the sample averages, an additional patent application or active license is likely to have a small marginal effect on the institutional environment, so we use a logarithmic transformation of these variables. Start-up companies formed based on the research provided in year t ($StartUps_{it}$) may require more intensive and active involvement of faculty and graduate students that produced the research in the operation of the company compared to licensing agreements with established firms. Start-up companies contribute directly to employment in academia, therefore we do not transform this variable.

We include control variables for two school types: Public universities may operate with a different accountability mechanism relating to state and federal governments. Medical schools usually have very different organizational contexts compared to schools of arts and sciences that conduct most basic research (This also applies to engineering schools). Moreover, because of the clinical and applied nature of the research at medical schools, it is reasonable to expect from them greater participation in more entrepreneurial activities. We use two (independent) dummy variables for public and medical schools. Schools with relatively greater focus on engineering may place a larger share of their PhD students in industry jobs. To control for this we calculate the share of PhD degrees in Engineering in all PhD degrees at every university using data from the *Science and Engineering Doctorate Awards* reports of the NSF.

We also introduce an indicator variable ($Post\ 2001_t$, that takes the value 1 for years that follow 2001, and 0 otherwise) that allows us to control for the change in macroeconomic conditions after the 2001 recession, which may have affected trends in career choices. Table I provides some descriptive statistics for the main variables used in our analysis.

A student fills the SED at time t after a period of job search, duration of which varies by discipline. The job applications (or the planning thereof) may start as early as $t-1$. In many cases, one's likelihood of a certain employment choice is affected by the choice of dissertation topic and/or thesis advisor(s), several years preceding the employment decision. For these reasons, the perception of industry vs. academia a few years before

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that will not require further training. This and missing variables in some other sporadic cases leave us with 743 observations. Our AUTM sample constitutes a large majority of the total science and engineering doctoral student population. Our estimation procedure handles the potential inconsistency problem using the Baltagi and Wu (1999) approach.

[4] This relative measure of industry support intensity measures the direct contact of universities and industry and is a proxy for student contact with industry.

the acceptance of the job offer is likely to be a better indicator of the institutional environment that shapes a student's choice. Here we present results with a reasonable lag of 3 years for our commercial research and university entrepreneurship measures.[5] We estimate equations of the following specification:

$$PCC_{i,t} = \beta_0 + \beta_1\, IndFedRatio_{i,t\text{-}3} + \beta_2\, log(NewPatents_{i,t\text{-}3}) + \beta_3\, log(Licenses_{i,t\text{-}3})$$
$$+ \beta_4\, StartUps_{i,t\text{-}3} + \beta_5\, Public_i + \beta_6\, Medical_{i,t} + \beta_7\, EngineeringShare_{i,t} + \beta_8\, Post\ 2001_t + u_{i,t}$$

where PCC_{it} (percent career choice) is the percentage of graduating students that made a particular career choice (industry/academic/post-doctoral) among those students with finalized post-graduation plans at university i in year t. The error term has the structure $u_{it} = \alpha_i + \upsilon_{it}$.[6]

We present our estimation results in Table II (tested and corrected for autocorrelation, AR(1), as necessary). A key finding here is the significant relationship between the industry share in universities' funding and the career choices of doctoral students, which broadly supports the hypothesis that more interaction with the private sector through funding may result in more doctoral students seeking private sector employment and commercial research careers. In particular, *IndFedRatio* has a positive (negative) and significant coefficient for career choice towards industry (post-docs). For example, if the *IndFedRatio* doubles from its sample average .166 to .332 (e.g., a doubling of industry funds holding federal funds constant) the percentage point of doctoral students shifting to industry careers will increase by .166x.044 = 0.007 percentage points. Given, for example, the number of 17,778 students with definite plans in 2005, this corresponds to roughly 130 additional students shifting to industry upon graduation.

The coefficients of licensing and start up activities are significant (and positive) only for post-docs as expected. This suggests staying in academia is likely encouraged by these activities. We interpret the insignificance of patent applications (for any career choice), licenses, and startups for Industry and Academic employment as an indication that: (i) *IndFedRatio* is a strong proxy for industry employment; (ii) Academic employment is determined mostly by the supply side. Note the significant coefficients of the professional schools: Engineering and medical degrees are strong determinants (positive and negative) in industry employment as expected. The same is observed with opposite signs for academic and post-doc employment. Public schools have a significant positive (negative) effect on academic employment (post-doc). Finally, the Post-2001 dummy has a significant negative (positive) effect on industry (academic and post-doc) employment, suggesting a shift away from the industry probably due to the recession in 2001.

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[5] The median registered time to degree was 6.8 year for S&E doctorates in 2003 (Science and Engineeering Doctorate Awards, NSF). An earlier version of this paper, available from the authors, presents estimates with current measures (lag 0) that are broadly consistent with the results herein.

[6] In this random effects specification, α_i represents the school specific component of the error term, which for each i and t has an identical and independent normal distribution $N(0,\sigma_\alpha^2)$. The second component υ_{it} has an identical and independent normal distribution $N(0, \sigma^2)$ for each i and t. Fixed effects estimates do not contradict in sign with random effects estimates when significant coefficient estimates are compared. In particular, *IndFedRatio* (logged and lagged three times) is never significant. Our sample is not exhaustive (see footnote 3) so we prefer random effects specification over fixed effects.

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Table I: Summary Statistics

Variable	Mean	St.Dev.	Min	Max
Percent Industry	0.231	0.094	0.059	0.573
Percent Academic	0.224	0.067	0.068	0.454
Percent Postdoc	0.429	0.099	0.103	0.708
Ind/Fed Research Support Ratio	0.166	0.173	0	1.582
New Patent Applications	42.4	64.2	0	601.00
Active Licenses	129.9	213.4	0	1654
Start-ups	2.37	3.44	0	31
Proportion of Engineering PhD's	0.136	0.137	0	1.0
Medical	0.591	0.492	0	1.0
Public	0.698	0.459	0	1.0

Upper panel: SED data (N=743), lower panel: STATT data (N=1346)

Table II: Estimation Results

	Industry Employment		Academic Employment		Postdoctoral Appointments	
IndFedRatio	0.04402	*	-0.00502		-0.06198	*
	(-0.02126)		(0.01850)		(0.02716)	
logPatents	0.00644		-0.00393		-0.00133	
	(0.00485)		(0.00433)		(0.00594)	
logLicense	0.00177		-0.00659		0.01779	**
	(0.00476)		(0.00468)		(0.00636)	
StartUps	-0.00145		0.00012		0.00227	=
	(0.00098)		(0.00086)		(0.00120)	
Public	-0.00819		0.04370	***	-0.04252	**
	(0.01020)		(0.01106)		(0.01469)	
Medical	-0.03943	***	-0.00986		0.07324	***
	(0.01073)		(0.01123)		(0.01514)	
PropEngPhd	0.41369	***	-0.15037	***	-0.14824	**
	(0.03990)		(0.04026)		(0.05360)	
Post2001	-0.06835	***	0.01891	***	0.04564	***
	(0.00585)		(0.00470)		(0.00708)	

Standard deviations are given in parentheses. (=) P<0.10, (*) P<0.05, (**) P<0.01, (***) P<0.001