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## Science faculty at US research universities: The impacts of university research center-affiliation and gender on industrial activities<sup>☆</sup>

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### ABSTRACT

Academics work in increasingly complex institutional environments. Universities become more engaged with commercial activities at the same time that they generate new internal structures to manage research activities. Faculty members are the principal agents through which these interactions develop and mature. How these institutions and industrial arrangements affect faculty career management continues to be investigated in recent work. We use scientific and technical human capital theory to test the hypothesis that university research center-affiliation helps to facilitate valuable industrial involvement by university professors. We are particularly interested in how gender may moderate the effects of university research center-affiliation on industrial activities. We study tenure-track academic scientists and engineers in US research universities to find that affiliation with a university research center increases the industrial involvement of both men and women. We conclude that the development of university research centers has resulted in a new basis of institutional stratification among professors, with affiliates engaging in more industrial activities than their exclusively department-based peers. Although university research center-affiliation advantages both men and women, male university research center-affiliates enjoy a slightly greater advantage than female center-affiliates in their industrial involvement.

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### 1. Introduction

In the period since 1980, three significant trends emerged in the academic sector focused on science and engineering. First, academic researchers and universities became more involved in industrial and commercial activities in myriad ways ([Etzkowitz et al., 1998](#); [Owen-Smith and Powell, 2001](#)). Second, university research centers grew in importance throughout the developed world as policy makers increasingly recognised the need for boundary spanning institutions of this type ([Bozeman and Boardman, 2004](#); [Nursall, 2003](#); [Rasmussen et al., 2006](#); [Rogers et al., 2001](#)). Finally, women's representation among credentialed scientists increased dramatically ([National Research Council, 2001](#)). These trends—and their implications for institutions and individual careers—have been studied separately extensively,

but the interactions among them are still poorly understood ([Mangematin, 2001](#)).

In this study, we focus on how gender and institutional location within universities influence the pattern of industrial interactions by tenured and tenure-track scientists and engineers working at research extensive universities in the United States. Scientific and technical human capital theory ([Bozeman et al., 2001](#)) conceptualizes the formal and informal human and social capital that is particular to the professional activities of scientists. As such, both industrial involvement and affiliation with university research centers constitute important indicators of scientific and technical human capital. We posit that the location of academic scientists within university research centers creates differential opportunities for industrial interactions outside the university. Following a rich tradition of research documenting male–female differences in access to scientific resources, we posit that female academic scientists will have fewer industrial interactions. Combining the theoretical and empirical perspectives, we are able to evaluate the extent to which institutional location in a university research center and gender affect the pattern of industrial involvement. In this way, we investigate the extent to which gender moderates the effects of university-based institutional location on industry affiliation.

We find that over half of the professors in our sample work in some capacity with private industry, while 40% are affiliated with

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a university research center. Consistent with our prediction, affiliation with a university research center increases industrial involvement. We find that male professors engage in a broader array of industrial activities, and at a higher level. In particular, male professors are much more likely to be paid by an industrial firm, to work for or own a private company, and to work with industry to commercialise a product. In multivariate analysis, we find that affiliation with a university research center continues to exert direct positive effects on industrial involvement, and that male center-affiliates are particularly advantaged by university research center-affiliation.

We begin the paper by discussing the relationship between universities, university faculty and industry in the United States, followed by a discussion of the role that university research centers play to facilitate the interactions between academia and industry. In each of these sections, findings related to the moderating effects of gender are described. After specifying our hypotheses, we present our research design and findings, which are based on 1596 professors in US research universities. We follow the presentation of univariate, bivariate, and multivariate results with a discussion of study limitations.

## 2. Theoretical background

### 2.1. Industrial affiliations by university faculty

The relationship between universities and industry is a topic of considerable interest among students of technology throughout the world (Baldwin and Link, 1998; Gonard, 1999; Gray, 1998; Gray et al., 2001; Mansfield and Lee, 1996; Nursall, 2003; Wong, 1999). In the United States, industry is the number one performer of research and development (R&D) work; in 2004, companies spent \$208 billion, compared with federal outlays of 97.3 billion to all performers (NSF, 2006a). This trend in greater industrial expenditures than federal on R and D has persisted since the early 1980s (NSF, 2007). Despite relatively small direct monetary contributions, the National Science Foundation points out that the amounts may reflect a diversity of activities between universities and industry that do not easily simplify into a dollar amount, a key issue we will develop in our measurement of industrial involvement (NSF, 2006b). We are interested in a diverse array of ways that researchers are involved with industry, and not just in discrete economic outputs.

Resources to engage in scientific research are crucial to the success of academics; industrial interaction is one way to develop scientific and technical human capital that enhances the available resource base (Bozeman et al., 2001; Murray, 2004). The importance of industrial funding to the development of scientific and technical human capital has been demonstrated with respect to patenting and funding (Dietz and Bozeman, 2005; Lin and Bozeman, 2006). The benefits of publicly funded research in universities are transferred to industry through scientific personnel exchanges (Paterson, 1999; Zellner, 2002) and entrepreneurial firms are advantaged by the social capital scientists bring to them (Murray, 2004). Other research has documented that industry attends to the quality of faculty when making its research and development investment decisions (Powers, 2003). In some disciplines, particularly the life sciences at universities with medical schools, up to 28% of faculty report receiving some industrial support (Blumenthal et al., 1996).

Both male and female scientists experience gains from industrial involvement. However, mounting evidence suggests that industry-specific types of scientific and technical human capital are disproportionately invested in by men (Azagra-Caro, 2007). In recent work, Thursby and Thursby (2005) found that

women are less likely to disclose intellectual property. Other research indicates that women tend to patent less, even though their scientific quality as measured by citation and journal impacts is similar to their male peers (Ding et al., 2006; Whittington and Smith-Doerr, 2005). In a more extensive treatment of women in science, Smith-Doerr (2004) finds that institutional context is very important for understanding gender differences. She finds that female academics are least likely to patent, while female scientists in industry—relative to their female counterparts in the academy—tend to patent more and to be more likely to head laboratories. Although younger cohorts of women feel more comfortable with commercialisation processes than their older colleagues, gender differences remain in commercial activities (Murray and Graham, 2007).

To summarise, we argue that industrial involvement constitutes a potentially resource-rich component of scientific and technical human capital development. Just as it has tended to increase the welfare of institutions that engage in it, it tends to enhance the resource base (broadly defined) from which scientists do their work. Recent research indicates that the relationship between gender and industry-related institutions is complex, depending a great deal on the nature of the activity and the character of the institution to understand its effect. In the next section, we describe one of the major organisational components universities employ to facilitate research in general, and interactions with industry in particular.

### 2.2. University research center-affiliations

In the United States, professors are free to involve themselves with industry without formal university sanction. Not all organisational positions within US universities are equally likely to facilitate such arrangements, however. An additional institutional resource that facilitates the development of scientific and technical human capital is affiliation with a university research center, which may or may not have formal industrial ties (Bozeman and Boardman, 2004). Such centers are organisational creations of the post-war era, and have been studied formally for some time (Ikenberry and Friedman, 1972). University research centers are one kind of specific mechanism by which increasing interactions between industry and universities is channeled; these institutions create organisational bridges that span the boundaries created by the disparate cultures and structures of universities and industry (Gray, 1998; Nursall, 2003).

University research centers are not solely creatures of industry, however. Although such centers do pursue nonacademic objectives, most notably industrial support and applications, they also serve as loci for multidisciplinary and basic research (Friedman and Friedman, 1985). Because of their diverse activities, university research centers tend to have complex funding streams, to have heterogeneous research portfolios, and to pose greater managerial challenges than more traditional academic activities (Gray, 2000). Friedman and Friedman (1985) warn, however, that the flexibility and transience of the organised research unit model may be overstated due to institutional dynamics that promote organisational longevity, and a tendency to be influenced by departments from which academic career awards flow (Ikenberry and Friedman (1972)). In general, the impacts of university research centers tend to be diffuse, encompassing commercial, educational, and social outcomes (Corley and Gaughan, 2005; Gray, 2000; Bozeman and Gaughan, 2007).

The majority of work on university research centers is focused on the institution-to-institution arrangements that are made between universities and their centers or between universities and industry (Baldwin and Link, 1998; Cohen et al., 1998; Gonard,

1999). We are primarily interested in the relationship between individual researchers and institutions, notably those affiliated with university research centers and engaged with industry. In this dynamic, relatively little research has been done. Forty percent of scientists and engineers are university research center-affiliates, which indicate that center-affiliation is an important part of many academic careers (Corley and Gaughan, 2005).

Research centers may create more gender neutral institutional settings because they are more recent institutional structures that have been organized at the same time that increasing numbers of women joined the scientific labor force. Work on a selected group of center-affiliates found that men and women did not vary in their ability to get grants, or their amounts (Gaughan and Bozeman, 2002). More recent work on a representative sample disaggregated university research center and gender effects on a range of core academic activities. That research found that men and women in centers were advantaged by higher levels of grant support, more graduate students, and fewer undergraduate responsibilities. These are all factors that would enhance the development of scientific and technical human capital. These dynamics did not differ by the gender of the university research center-affiliate, except for one key indicator: engaging in paid consulting work (Corley and Gaughan, 2005). That research is limited, however, by a narrow conception of industry work (paid consulting), which did not conceptualise industrial involvement broadly as we do here.

### 2.3. A theoretical integration and extension

To date, there has been little empirical attention to how restructuring of the academic sector affects scientific careers in general or those of women in particular. Recent work determined that both gender and university research center have strong direct and interactive effects on a variety of indicators of core academic activities. Faculty researchers engage in a wide variety of types of activities with industrial partners. Although paid work is important, it may not be the most important component of industrial involvement. Other activities such as joint publishing and routine scientific communication are not likely to be paid, but are likely to increase the non-pecuniary capacity to engage in scientific work, which is the essential feature of scientific and technical human capital.

Here, we examine how the institutional setting of university-based research centers has differential impacts on various aspects of industrial involvement by academic researchers. We are further interested in how the gender of the affiliated researcher affects such industrial involvement. Thus, we seek to examine how industrial involvement varies by institutional context (university research center vs. non-center-affiliate), and by gender.

**H.1.** Faculty affiliated with university research centers will engage in a greater degree of industrial involvement than their exclusively department-based colleagues.

**H.2.** Male academics will be more involved with industry than female academics.

**H.3.** Gender will moderate the effects of university research center-affiliation and industrial involvement.

In other words, we expect that women affiliated with university research centers will be involved with industry to a lesser extent than their male colleagues who are also center-affiliates, but to a greater extent than their female colleagues who are exclusively department-based.

## 3. Research design and data collection

### 3.1. Sample

A major limitation of earlier work examining the interactions of university research center-affiliation and career development is the selected nature of the samples; specifically, most research studies target university research centers, and then select professors affiliated with those centers (Corley et al., 2005). The purpose of this study was to estimate the percentage of faculty in research extensive universities who are affiliated with university research centers. Hence, the focus was not on identifying centers, and then the faculty affiliated with them; rather the focus was on drawing a nationally representative sample of tenured and tenure-track professors and then asking them about university research center involvement. Therefore, a primary aim of the research design was to avoid known problems of sample selection, in which the behavior of center-affiliates is studied without the ability to study the behavior of faculty who are not affiliated with university research centers.

With our design purpose in mind, we first listed all of the departments in 150 Carnegie research extensive (2000) universities that grant Ph.D.'s in the following National Science Foundation scientific disciplines: biology, computer science, mathematics, physics, earth and atmospheric science, chemistry, agriculture, and five sub-disciplines of engineering. The Carnegie Foundation for the Advancement of Teaching was established as an independent policy institution in 1905; one of its major contributions to higher education is to generate periodic classifications of the 4400 institutions of higher education in the United States for the purposes of research. The 151 research extensive universities used in this study (Carnegie, 2000) are broadly comparable to the major national research universities of Europe, the Commonwealth, and the most developed countries of Asia; examples of these universities include private universities such as Harvard and Stanford, and public universities such as Michigan and the University of California at Berkeley. The 2000 classification is used by the National Science Foundation to generate its research rankings. These are the major US research universities and those most likely to be engaged in industrial activities: for example, over one-quarter of the top 200 world universities ranked by *THE-QS* (2008) are used to generate our sample frame.

After enumerating the population of target departments within universities, we then developed a comprehensive list of every tenured and tenure-track faculty member in the census of departments. From the resulting sampling frame of 36,874 names of faculty; we sampled 4916, which yielded a questionnaire response rate of 38%. Women were over-sampled to ensure the ability to make gender-based comparisons. In multivariate analyses, we follow Winship and Radbill (1994) in controlling for the disciplinary and gender stratification to account for sampling design effects. The study was completed in 2004–2005.

### 3.2. Measures and descriptive statistics

Our primary dependent variable is a weighted industry involvement scale based on a set of questions related to industrial activities asked of all respondents. Table 1 shows the distributions for the single items that comprised the weighted industry involvement scale, as well as differences related to university research center-affiliation and gender.

Over half of the respondents report some type of working relationship with a private company in the last 12 months. When we analyse the industry involvement of center unaffiliated respondents (i.e., the middle panel of Table 1), we find that

**Table 1**  
Means and standard deviations for industry variables by institutional affiliation and gender.

Variables	All		Department only (means)		Department+center-affiliated (means)	
	Mean (n=1596)	SD	Women (n=472)	Men (n=498)	Women (n=343)	Men (n=283)
<i>Industry Involvement Scale</i>						
Weighted Industry Involvement Scale	1.08	1.44	0.80	0.94	1.15***	1.68***
<i>Components of Industry Involvement Scale</i>						
Private company asked for info about research and it was provided (%)	37.5	48.4	31.6	30.7	44.6	50.5
Contacted persons in industry about their research (%)	19.2	39.4	16.9	14.5	20.7*	29.3*
Served as formal paid consultant to an industrial firm (%)	18.2	38.6	11.2***	20.7***	16.6**	27.2**
Helped place graduate students or post-docs in industry jobs (%)	25.4	43.5	19.9	20.3	28.3**	39.9**
Worked at company with which I am an owner or employee (%)	3.6	18.6	1.3**	4.2**	1.7***	8.5***
Worked directly with industry in work that resulted in a patent or copyright (%)	5.4	22.6	3.6	4.4	5.8	9.5
Worked directly with industry in effort to commercialise or transfer technology (%)	16.2	36.8	10.6*	14.9*	16.9**	26.9**
Coauthored a paper with industry personnel that was published (%)	15.2	35.9	10.8	12.7	17.2**	24.7**

$\chi^2$  test for component variables: \*\*\*  $p < .001$ ; \*\*  $p < .01$ ; \*  $p < .05$ .

Independent samples *T*-test, 2-tailed for "Weighted Industry Involvement Scale": \*\*\*  $p < .001$ ; \*\*  $p < .01$ ; \*  $p < .05$ .

female faculty are significantly less likely than their male peers to serve as a formal paid consultant to an industrial firm, work at a company that they own or are employed by, and work with industry to commercialise technology. These gender differences continue to hold for the center affiliated faculty members (i.e., the right panel of Table 1). There are some additional gender differences in the industry involvement patterns for center-affiliated faculty. Female center-affiliated faculty are significantly less likely than their male counterparts to contact people in industry about their research, help place graduate students and post-docs in industry jobs, and co-author a paper with industry personnel. Thus, without controlling for other variables, these results suggest that center-affiliation may increase the industry involvement of male faculty members more than it does for female faculty members.

In the top row of Table 1, we present the gender and center-affiliation differences for the weighted industry involvement scale, which is our dependent variable in multivariate analyses. This scale was constructed by using the single item indicators that we just discussed to develop a weighted industry involvement scale. This scale was first developed by Bozeman and Gaughan (2007). Boardman (2008) recently used the measure to determine that NSF-supported biotechnology centers facilitate industrial networking by faculty. The scale incorporates many of the modes of interaction identified by Geisler and Rubenstein (1989) as critical indicators of the intensity of interaction between university researchers and industrial partners. It is calculated by measuring the proportion of respondents participating in each of the industry items—and then using the inverse of that proportion as a weight.<sup>1</sup> For example, 18.2% of the respondents have served as a formal paid consultant to a private company. Therefore, engaging in that activity received a weight of .818. The weights for all types of activities in which the respondents were engaged were then summed, creating a weighted Industrial Involvement Scale. For the sample presented here, the Industrial Involvement Scale ranges between 0 and 6.59 with a mean of 1.08. The scale has the following properties: an alpha reliability of .78, and normal distribution (skew=1.3; kurtosis=1.0). Thus, it meets the requirements for ordinary least squares (OLS) regression.

<sup>1</sup> The preceding discussion relied on more intuitively appealing percentages to convey the range and depth of industrial activities by faculty.

Note that our conceptualisation of the industrial involvement construct is much broader than traditional indicators such as patenting and commercialisation, and that there is a tremendous amount of diversity in involvement. For example, only 5% reported work with industry that resulted in a patent or copyright. By contrast, 37% provided research-related information to a private company upon request. When looking at industry involvement across center-affiliation and gender, we find that center-affiliates engage in significantly more industrial activities than their unaffiliated peers, while women engage in significantly fewer than men. These simple bivariate findings underscore the importance of studying center and gender effects on industrial involvement simultaneously. Further, the results presented in Table 1 suggest that center-affiliated male faculty score significantly higher on the weighted industry involvement scale than center-affiliated female faculty. The gender difference is not significant for unaffiliated faculty members. This finding further supports our earlier hypothesis that center-affiliation is more beneficial for male faculty in terms of providing industry linkages.

### 3.3. Control variables

Our primary independent variables are the respondent's gender, his or her university research center affiliation status, and the interaction between these two variables. These two variables allow us to examine group differences between men and women, as well as between university research center and exclusively department-affiliated academics (bearing in mind that because of the department-based sampling frame, all center-affiliates are also department-affiliates). After completing the items that comprise the Industry Involvement Scale, all respondents were asked to indicate whether they were affiliated with a university research center, defined in the instrument as, "a research institution that has five or more faculty and postdoctoral researchers and includes participants from more than one discipline and more than one academic department."<sup>2</sup>

We include a number of control variables for theoretical reasons. First, because the demographic characteristics of the

<sup>2</sup> Note that our definition is more restrictive than Friedman and Friedman's (1985) definition of Organised Research Units, which included centers, institutes, labs, bureaus, and clinics. We retain the important distinction that the research center may not be housed in a department.

**Table 2**  
Descriptive statistics of independent variables.

Variables	All		Department only (means)		Department+center-affiliated (means)	
	Mean (n=1596)	SD	Women (n=472)	Men (n=498)	Women (n=343)	Men (n=283)
<i>Demographic and institutional variables</i>						
Male	48.9%	0.50	–	–	–	–
Center-affiliate	39.2%	0.49	–	–	–	–
Age	48.5	10.54	45.4***	52.3***	45.1***	50.8***
Caucasian	81.8%	0.39	85.2%***	75.7%***	86.6%	81.3%
Asian	11.4%	0.32	9.1%**	15.7%**	9.3%	10.2%
African American	1.2%	0.11	1.5%	1.4%	0.6%	1.1%
Hispanic	2.9%	0.17	2.8%	3.6%	2.6%	2.1%
Native American	0.4%	0.07	0.2%	0.6%	0.6%	0.4%
<i>Career trajectory variables</i>						
Ph.D. year	1986	11.10	1990***	1982***	1990***	1983***
Ever a postdoctoral fellow	50.3%	0.50	50.4%	47.7%	51.9%	52.7%
Tenured	71.1%	0.45	62.9%***	79.5%***	65.0%**	77.4%**
<i>Disciplinary fields</i>						
Biology	7.7%	0.27	7.2%	8.2%	7.3%	8.1%
Computer science	8.5%	0.28	10.8%	7.8%	8.2%	6.4%
Maths	6.6%	0.25	7.8%	9.0%	4.4%	2.8%
Physics	9.3%	0.29	10.8%	10.4%	9.0%	5.3%
Atmospheric sciences	10.5%	0.31	11.2%	9.0%	11.7%	10.2%
Chemistry	8.5%	0.28	7.8%	7.6%	8.7%	10.6%
Engineering	40.8%	0.49	36.4%	38.4%	43.7%	48.8%
Agriculture	8.1%	0.27	7.8%	9.4%	7.0%	7.8%

$\chi^2$  test for binary variables across gender and within institutional affiliation: \*\*\*  $p < .001$ ; \*\* $p < .01$ ; \* $p < .05$ .

Independent samples *T*-test, 2-tailed across gender and within institutional affiliation for "Year of Ph.D." and "Age" \*\*\*  $p < .001$ ; \*\* $p < .01$ ; \* $p < .05$ .

populations of male and female academics differ, we control for professional age (calculated as years since Ph.D.), and whether or not the person is tenured, a status that determines preference for industrially relevant research (Boardman and Ponomariov, 2007). Although there is no gender difference, we also control for whether the scientist has ever held a postdoctoral position; we reason that taking a postdoctoral position signals exclusive interest in an academic career, which may translate into less interest in working with industry later in the career. Disciplinary differences have been documented in previous research and, thus, we control for those as well (Becher, 1994). We use biology as our reference category, controlling for computer science, mathematics, physics, atmospheric sciences, chemistry, engineering, and agriculture.

We present general descriptive statistics for the sample in Table 2. There are 1596 professors in our analytic sample. Men and women are equally represented, reflecting the sampling design. Nine hundred seventy are exclusively department-based, and 626 are center-affiliated. In the sample as a whole, 82% are white and 39% are center-affiliated. The average faculty member received the Ph.D. in 1986; 71% are tenured, and half have held a postdoctoral fellowship. Examining these characteristics by gender and institutional context, it is important to recall the two primary bases for sample stratification were departmental affiliation and gender.

As expected, women are at younger career ages, completing their Ph.D. degrees 8 and 9 years later than men in the unaffiliated and center-affiliated institutional structures, respectively. Additionally, women are less likely to be tenured than male faculty for both center-affiliated and unaffiliated faculty. Interestingly, however, this discrepancy between the percentage of men and women with tenure is larger for unaffiliated faculty (even though the difference in Ph.D. degree years is less for that group). Without controlling for any other variables, this result indicates that center-affiliation might help women faculty move up the

academic ladder more quickly in comparison with their male peers.

In the last portion of Table 2, we provide descriptive statistics for disciplinary fields that were included in the sample. About 41% of the respondents were in the engineering fields, followed by about 11% in Atmospheric Sciences, and about 9% in Physics. The fields with the fewest number of respondents were Computer Sciences, Chemistry, Agriculture, Biology and Math. There were no significant differences in the percentages of male and females across center affiliation status—which is not surprising given that our sampling framework was designed to ensure that we had high levels of representation by women in all fields.

#### 4. Results

To analyse industry involvement further while controlling for career and disciplinary variables, we used the weighted industry involvement scale as the dependent variable in an ordinary least squares regression. The regression results are presented in Table 3. We present nested models in order to investigate direct and indirect effects, and to compare the fit of models directly.

In all four of the models, we controlled for career trajectory and disciplinary affiliation variables. The results of these background controls are consistent across models: career age has no effect, having ever been a postdoctoral fellow has a negative effect, and tenured status has a positive effect. Computer scientists, engineers, and agricultural scientists are significantly more likely than biologists to be engaged with industry; while other scientists do not differ from biologists in their tendency to be involved with industry.

In model 1, we explore the effect of gender on industrial involvement, controlling for the background factors already described and discussed. Men are significantly more likely to be involved with industry, a finding that we expected based on a

**Table 3**  
Regression of weighted industrial involvement scale on gender, career, and disciplinary affiliation.

Independent variables	Model 1: gender		Model 2: center		Model 3: gender and center		Model 4: gender × center	
	Unstd. coeff.	S.E.	Unstd. coeff.	S.E.	Unstd. coeff.	S.E.	Unstd. coeff.	S.E.
<i>Demographic and institutional variables</i>								
Male	0.18**	0.1	–	–	0.21**	0.1	0.09	0.1
Center-affiliate	–	–	0.41***	0.1	0.42***	0.1	0.29**	0.1
Male × center-affiliation	–	–	–	–	–	–	0.29*	0.1
<i>Career trajectory variables</i>								
Ph.D. year	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Ever a postdoctoral fellow	–0.22**	0.1	–0.24**	0.1	–0.24***	0.1	–0.25***	0.1
Tenured	0.42***	0.1	0.40***	0.1	0.41***	0.1	0.41***	0.1
<i>Disciplinary field variables<sup>a</sup></i>								
Computer science	0.72***	0.2	0.73***	0.2	0.73***	0.2	0.72***	0.2
Maths	–0.32	0.2	–0.25	0.2	–0.25	0.2	–0.25	0.2
Physics	–0.08	0.2	–0.06	0.2	–0.04	0.2	–0.04	0.2
Earth and atmpsp. Sciences	0.03	0.2	0.01	0.2	0.02	0.2	0.01	0.15
Chemistry	0.32*	0.16	0.29	0.2	0.29	0.2	0.29	0.16
Engineering	1.19***	0.14	1.17***	0.1	1.15***	0.1	1.15***	0.13
Agriculture	1.01***	0.17	1.03***	0.2	1.02***	0.2	1.02***	0.17
Intercept	–3.06	7.5	4.09	7.1	–2.52	7.4	–2.34	7.4
Adjusted R <sup>2</sup>	0.20		0.22		0.22		0.22	

\*\*\**p* < .001; \*\**p* < .01; \**p* < .05.

<sup>a</sup> Reference Group: Biologists.

large volume of empirical research documenting male–female differences. In model 2, we find that center-affiliates are significantly more likely to be involved with industry, consistent with previous research. In the last two models, we investigate the direct and joint effects of gender and center-affiliation. In model 3, we test a theory that assumes that gender and context have independent direct effects on industrial involvement, finding that there is support for an independent direct effect of each variable. The magnitude of the center affiliation variable is twice that of the gender variable, suggesting that center-affiliation may be more important than gender in predicting industry involvement. In model 4, we test the model using the interaction of gender and center-affiliation as the final control. In this specification, the direct gender effect disappears, and the center affiliation variable loses magnitude (but not significance). The interactive effect is significant, indicating that male center-affiliates are especially likely to be involved with industry; female center-affiliates still benefit from direct center-affiliation (relative to their exclusively department based male and female colleagues). It should be noted that other direct effects already noted remain the same.

When examining the fit of the last two models, we have little empirical basis for choosing one over the other: each explains roughly 22% of the variance. For theoretical reasons, however, we favor the interactive model. The fully interactive model indicates that the relationship university research center and industrial involvement is moderated by gender, consistent with our theoretical framework.

### 5. Study limitations

A limitation of the research is that the causal relationship between industry involvement and university research center-affiliation is unknown. On the one hand, faculty who are involved with industry may be more likely to affiliate with university research centers. On the other hand, faculty who are affiliated with university research centers may be more likely to be involved with industry. The estimation of endogeneity bias is a difficult one in all analyses of this topic; to our knowledge, it has not been resolved because longitudinal data that would allow

specifying temporal priority has not been collected. Since our study relies on a cross-sectional survey, we have a limited ability to sort such temporality out with this dataset. We argue that university research center-affiliation affects industry involvement because such affiliation constitutes a more significant institutional investment than the majority of activities captured in the weighted industry involvement scale. Furthermore, we asked respondents to report about industry activities in the last year, limiting the extent to which industry activity can predate current university research center involvement. A top priority for further research is to specify when, exactly, center-affiliation occurs relative to industry activity.

It should be emphasised that these results are generalisable to scientists and engineers employed as tenured and tenure track scientists in research extensive universities in the United States. Although this is an important sector when considering research and innovation, we do not claim to make inferences to other national contexts. National context is important because so much of the relationship between universities, researchers and industry occur within the context of national and multinational policy. By focusing only on professors working on faculties of United States universities, we eliminate country-level policy variation to capitalize on exploring within-country variation. Given diversity in the organization of higher education systems throughout the world (not to mention significant reform efforts currently ongoing), it would be quite interesting to study how affiliation with university research centers affects industry involvement, and the extent to which that may be moderated by gender in other national and supra-national contexts.

Generalisation within the United States is further limited: one should use caution in making inferences to other types of universities, academic researchers who are not on the tenure track, or academics working outside science and engineering disciplines. We do not consider these serious limitations for the purpose of understanding the relationship between university research centers and industrial involvement. As we have already discussed, we study science and engineering professors in only 150 of the thousands of institutions of higher education in the United States. The scientific and engineering disciplines are the ones most likely to be attractive to industry, and the 150

universities for which these professors work are the major research universities in the United States, producing the vast majority of Ph.D.'s and engaging in the majority of government and industry-sponsored basic and applied research. Professors at other types of higher education institutions (for example, two year community colleges, private for-profit colleges, and small liberal arts colleges), or in humanities fields, are less likely to be attracted or attractive to industry. A final note is that significant restructuring is occurring within higher education in the United States whereby increasing percentages of faculty do not have permanent employment. In effect, they are contracted teachers who have limited opportunities to engage in the research functions of the university. As such, professors not on the tenure track are also not going to have affiliations with university research centers or significant industrial involvement.

## 6. Discussion and conclusions

In this research, we were interested in explaining variation in industrial involvement among academic scientists and engineers. Industry–academic relationships have been steadily increasing for the past quarter century, and faculty are one of the principal agents of this relationship. Furthermore, gender differences within academic careers are well documented; we are interested in the way gender operates at one of the intersections between university and industry—that of the university research center. We found that center affiliated researchers are especially likely to be involved in a range of industry-related activities relative to their exclusively department-based colleagues. We also found that center affiliated men are particularly advantaged in the development of industrial interactions. To the extent that industrial involvement constitutes a valuable component of scientific and technical human capital, institutional location within a university research center is advantageous to its development, while being a center affiliated male is particularly advantageous. Despite many years of attention to reducing gender differences in science, gender gaps remain. The importance of this research is to underscore the importance of intra-university institutional factors in affecting access to industrial involvement, and to show that institutions continue to be a prism through which gender operates differentially.

The issue of the educational mission of universities, and how that may be affected by university research centers and industrial involvement is certainly an important one, but beyond the scope of this paper. In research using the same data we use here, university research center-affiliates tended to support and supervise more graduate students, but to teach fewer undergraduate students. There were no differences between center-affiliated and departmental affiliated professors in their service obligations to either the university or the profession (Corley and Gaughan, 2004).

We have evaluated how gender and institutional affiliation affect one important component of scientific and technical human capital: that of industrial involvement. We have argued that gender and institutional locations create stratification in industrial affiliations. We further argue that such involvement helps to develop scientists' capacity to engage in research and to advance in their careers. In this study, we look only at the first part of this theoretical relationship. In the next phase of this research, we will investigate how the differential gender and affiliation effects on industry may affect other aspects of the academic scientific career such as publication productivity and career velocity. This work falls under our larger theoretical interests of specifying how and under what institutional conditions gender may affect scientific career development. To the extent that policy makers are

interested in closing the gender gap in scientific achievement, basic research of this sort helps to illuminate the mechanisms through which gender stratification persists in science.

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