Scientists' Participation in University Research Centers: What are the Gender Differences?

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ABSTRACT. University-affiliated multidisciplinary research centers have grown in importance in academia. Most research to-date has focused on these centers from an institutional perspective, with recent work only beginning to explore the ways in which such centers affect the development of academic careers. Hence, little is known about how scientists who are center-affiliated differ from those who are not affiliated. Clearly, both selection and influence effects may be expected to operate in terms of research productivity, timing, and resources. A further puzzle is how center affiliation may differ between male and female scientists. In this study, we use a new, nationally representative dataset of scientists and engineers working in Carnegie Research Extensive universities to develop an understanding of how center-affiliated scientists differ from exclusively department-based academic scientists and engineers, and investigate the extent to which gender moderates the effects of centers. As expected, our national sample shows that women are younger, whiter, less likely to be tenured, and at a lower rank than their male colleagues. We find that women are as likely to join centers as men, and do so at a similar stage in their career. Most of the male–female differences observed in disciplinary settings are sustained in centers, but women appear to have greater research equality in them (compared to the departmental setting). In particular, men and women in centers spend the same amount of time writing grant proposals, conducting both grant-supported and unfunded research, and administering grants. This suggests that centers may constitute an institutional context in which some aspects of gender equity in science may be achieved.

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1. At the forefront of US production of scientists and engineers

The development of national research infrastructure is central to the American innovation system, and the Research Extensive universities are a crucial component of that engine of growth (Crow and Bozeman, 1998). A large body of work has demonstrated that female academic scientists remain disadvantaged in their access to research resources, and the rewards that attend them such as productivity and career progression. However, this work has focused almost exclusively on scientists in traditional academic departments. A question we believe has received insufficient attention is what role the development of university-based research centers, in which 40% of academic scientists and engineers now work, plays in the career prospects and patterns of underrepresented groups. In this paper, we seek to explore how centers and departments differ in creating contexts for female academic career success. Our own earlier work leads us to expect that centers create different opportunity structures for female scientists; in this study, we use a better sampling strategy to investigate our earlier findings (Gaughan and Bozeman, 2002; Corley *et al*., 2003; Bozeman and Corley, 2004).

We briefly recapitulate the findings about women academic scientists, bearing in mind that this special issue addresses the literature comprehensively. We focus especially on university-based research centers as new organizational contexts for scientific career development. We find there are few studies that link the direct effects of university-based science centers on academic scientists, or that provide clues to how faculty members perform in them. There is enough work, however, to use the two literatures to generate hypotheses to evaluate men's and women's experiences in university-based science centers at Research Extensive universities. We then test these hypotheses using data from the 2004 Survey of Academic Researchers completed by the Research

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Value Mapping Program at Georgia Tech (Barry Bozeman, PI). Finally, we draw some general conclusions about how our results may inform science policy within university-based science centers.

2. Academic women in science

By the 1990s the promise of affirmative action to redress gender inequity in universities had largely been realized (Cole, 1979; NRC, 1987, 2001). Yet women remain under-represented in the senior tenured ranks, and over-represented in off-ladder positions (Barber, 1995; NRC, 2001). Early work on scientific careers evaluated how science is socially stratified by a variety of ascriptive and acquired traits (Cole and Cole, 1973). This generated a stream of research that evaluated the determinants of women's lower academic career success (Long and Fox, 1995). The university remains an employment sector that is highly sex segregated, with negative consequences for the women in it (Reskin, 1978; Bielby and Barron, 1986; Jacobs, 1996).

Xie and Shauman (2003) attribute gender differences in outcomes to gender differences in personal and structural characteristics that bear on typical scientific output measures such as publication productivity and research resources. Numerous studies have been conducted that elucidate some of the individual-level mechanisms for these differential career outcomes. For example, women have differential access to resources during training (Reskin, 1978; Fox, 1995), and experience less mentoring and collaboration during their career (Long and McGinnis, 1985). Also, they tend to be less productive, which has negative impacts on career progression (Long *et al*., 1993). Overall, women are thought to benefit less from organizational factors that improve productivity (Allison and Long, 1990; Long and McGinnis, 1991). On the job, female academics are more aware of and sensitive to the presence of organizational constraints (Fox and Ferri, 1992). These constraints tend to reduce productivity and collaboration activity of female scientists (Fox, 1991).

Given what is known about women in competitive academic science at universities, it is important to investigate how variations in the institutional context itself affect career development. Center affiliation is an important new basis of structural location in the academic structure, one we know little about in its place in the development of the academic career in general, or gender differences in particular. If center researchers are more productive, then center-affiliates can be expected to benefit from the same contextual boost that Allison and Long (1990) found in departments.

University-based research centers

Since the 1980s interactions between industry and universities have become increasingly important in the development of R&D conducted at US universities (Gray *et al*., 2001). According to Cohen and colleagues (1994) about 70 percept of industry's support for academic research is channeled through roughly 1100 industry–university centers that they identified in 1993.

As Boardman and Bozeman (forthcoming) have noted, in the US the past three decades could be credibly called the "era of inter-institutional research collaboration." Increasingly, US science funding agencies are supporting centralized, interdisciplinary research centers that represent a different institutional form from the decentralized, individual-investigator research of the past. Bozeman and Boardman (2004) use a detailed analysis of the National Science Foundation (NSF) Engineering Research Centers (ERCs) to demonstrate how the rise of university-based science centers has led to the development of a new institutional form for the execution of university-based research.

The National Science Foundation's Industry/University Cooperative Research Centers (IUCRC) Program, which originated in 1973, is one of the oldest government initiatives focused on cooperative research across the industry and university sectors (Hetzner *et al*., 1989). The purpose of the NSF IUCRC program is to strengthen the relationship between industrial firms and universities, especially colleges of engineering (Adams *et al*., 2001). In fiscal year 2000, the NSFs contribution to the centers was about $5.2 million; however, industrial and other external support of the centers totaled about $68 million in FY 2000 (National Science Foundation, 2005). Currently there are approximately 50 IUCRCs, all of which are administered by the Engineering Education

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and Centers Division at the National Science Foundation.

Managers of university-based science centers face many challenges that are different from the challenges faced by traditional, academic department directors: namely, how to manage research within a new organizational structure that involves researchers from different disciplines, who bring diverse collaboration incentives and research goals to center-based research (Boardman and Bozeman, forthcoming). Even though there is some early recognition that university-based science centers represent a new institutional form for the performance of scientific research (Bozeman and Boardman, 2003), few studies have focused on exploring the effects of the new institutional form on individual scientists careers. In fact, many of the past studies on university-based science centers have concentrated on centers that explicitly involve university–industry collaborations (Jaffe, 1989; Rees, 1989; Cohen *et al*., 1994; Rosenberg and Nelson, 1994; Mansfield and Lee, 1996; Narin *et al*., 1997). Many focus on the study of industrial-university cooperative research centers (IUCRCs), which are defined as "small academic centers designed to foster technology transfer between universities and firms" (Adams *et al*., 2001, p. 73). The literature in this area, however, largely explores how IUCRCs affect organizations that participate in the centers—i.e., universities or industrial firms (for example, Blumenthal *et al*., 1986; Geisler *et al*., 1991; Mowery, 1995; Cohen *et al*., 1998; Santoro and Chakrabarti, 1999; Adams *et al*., 2001; Gray and Steenhuis, 2003)—and not on the impacts of center affiliation for individual faculty participants.

Although the large majority of studies on IUCRCs focus on organization-level units of analysis, there are a few scholars who have attempted to determine (in a general way) how IUCRCs might affect individual researchers. Cohen *et al*. (1998) studied the impact IUCRCs have on university-level research. They argued that the rewards from university research traditionally come from reputation—largely because reputation promotes faculty mobility, and mobility leads to salary increases and teaching reductions. Therefore, Cohen and colleagues argued that the rewards of academic research depend largely on the dissemination of research findings and open access to science results.

Hetzner et al. (1989) also briefly mention the issue of individual faculty participation in IUCRCs. They report that faculty members expect research funding to flow from their participation in IUCRCs—especially because of the excessive proposal writing requirements placed on them as members of these centers. Additionally, Hetzner and colleagues say some faculty report that participation in centers leads to more interactions with other faculty, more support for student research, greater access to equipment, and improved consulting and research opportunities. Hetzner and colleagues conclude, therefore, that these centers appear to be supporting some of the traditional core of faculty activities.

We believe that science and engineering research centers truly are a new organizational form in academe—and that researchers participating in these centers experience new challenges (and, hopefully, new advantages) as a result of their center affiliation. Prior research informs how science centers can be more effective and/or productive, but the impact that those centers have on individual researchers' careers—especially women—is not developed. Since there is little published research in the impacts of center affiliation on individual faculty careers (in general) and female faculty (in particular), we use the intersection of the two literatures to create some new hypotheses for the research presented here.

Women and centers: unanswered questions

In this paper, we explore how the recent setting of university-based science centers may have differential impacts on (1) scientists in general and (2) female scientists in particular. In general, we hypothesize that university-based research centers expose scientists (of all genders, ethnic groups, and levels of seniority) to greater opportunities for research. Therefore, we believe that scientists conducting research through university-based research centers will have access to more research resources than those not participating in centers and have more time for research relative to other academic obligations.

We also expect to see differences in the advantages (and disadvantages) that women and men receive from their center affiliations. In particular, we hypothesize that women scientists are more

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likely to be affiliated with university-based science centers, are more likely to be disadvantaged by carrying heavier service obligations because of their center participation, and in general receive fewer individual benefits of their center affiliation (such as satisfaction with job and feeling appreciated by colleagues).

Stated formally, we make the following hypotheses:

H1 Center-based scientists have access to more research resources than department-based scientists.
H2 Center-based scientists have more time for research relative to other academic obligations.
H3 Female scientists are more likely to be affiliated with university-based science centers.
H2 Center-based scientists have more time for research relative to other academic obligations.
H4 Female scientists are more likely to be disadvantaged by carrying heavier service obligations because of their center participation.
H5 Female scientists are more likely to be disadvantaged by carrying heavier service obligations because of their center participation.

3. Research design and data collection

Earlier work that we have conducted on center-based researchers revealed no statistically significant differences between male and female researchers on likelihood of receiving grants, amount of grants, and publications (Corley *et al.*, 2003). We believe these findings are partially the result of the research design we employed. First, only researchers at Energy Research Centers and National Science Foundation Science and Technology Centers were included in the study. Second, only 13% of the study sample was female (which was, nevertheless, representative of those centers). We believe that gender-selection dynamics had already played out in the careers of these high-achieving female scientists in especially male-dominated disciplines. In the first study, we observe them after they have joined a multidisciplinary center, and we did not collect data that would have allowed us to compare them to exclusively department-based researchers.

In the current study, we solve many of the design limitations of the original center study. Rather than collect data from center-based researchers, we collect data from university-based researchers, many of whom are also center-affiliated. First, we study a representative sample of scientists and engineers in Carnegie Extensive Universities, allowing us to compare center-affiliated researchers with those who are not affiliated. Second, we extend the scope of our sample to disciplines likely to yield Center affiliations that are not exclusive to Energy Research Centers and NSF S&T Centers. Finally, we over-sample women scientists to ensure that there is sufficient sample size to understand gender dynamics—both between men and women, and within gender groups.

The data for the current study come from the 2004 Survey of Academic Researchers completed by the Research Value Mapping Program (Barry Bozeman, PI). Whereas the first study administration was targeted to center-based researchers, the 2004 study administration targets the population of scientists and engineers in tenure track (or tenured) academic positions at Carnegie Extensive universities (formerly known as Research I; Carnegie, 2000). Using the Carnegie list, we retained all universities ($n = 150$) that produced at least one Ph.D. in 2000 in at least one of 13 science and engineering disciplines. We excluded health sciences and economics from the National Science Foundation definition of science and engineering (NSF, 2000), and we subdivided engineering into five major specialties. The resulting disciplines include: biology, computer science, mathematics, physics, earth and atmospheric science, chemistry, agriculture, sociology, chemical engineering, civil engineering, electrical engineering, mechanical engineering, and materials engineering.

Having delineated the target population of universities and disciplines, we then collected the names of tenure-track faculty in each university by discipline. The list of faculty was obtained from (1) the on-line university catalog, or (2) the on-line departmental website. This resulted in a sampling frame of 36,874 scientists and engineers occupying a tenure track or tenured faculty position. The target sample was for 200 men and women from

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each of the 13 disciplines. Because the size of disciplines varies, as does the representation of women in each discipline, the sampling proportions varied from 0.21 (for women in biology) to 1.0 in five disciplines (e.g. the "sample" is actually a census of the women in the discipline). Men's sampling proportions varied from 0.06 in biology, to 0.23 in agriculture. The final target sample (accounting for women representing fewer than 200 in the discipline) was 4916.

Therefore, the 2004 Survey of Academic Researchers is unique in its ability to determine the representation of researchers in university-based research centers, and to make comparisons between those affiliated with them, and scientists who are not. In addition, the over-sampling of women means that gender differences can be evaluated by center affiliation and discipline.

The survey was administered by mail, focusing in particular on the following domains of faculty activity: funding, collaboration, institutional affiliations, and career timing and transitions. The survey also obtained basic demographic information about the researchers, their research-specific motivations and values, and the perceived benefits derived from their work. In this study, we focus on research resources and benefits, and teaching and service burdens as characteristics that we hypothesize differ between center affiliates and non-affiliates, and between men and women.

We obtained 1769 survey responses from scientists and engineers who were in tenure track positions, had an earned Ph.D., and who had complete information on center participation. There are 916 female respondents and 853 male respondents. There are 693 center-based researchers, and 1076 researchers who report departmental affiliations only (note, all center-based researchers also have a departmental affiliation).

4. Data analysis

We being our data analysis simply, examining univariate characteristics and bivariate differences by gender and institutional setting.

The first column shows the means and standard deviations of the 1769 scientists and engineers in the sample. About 82% are white, 39% are affiliated with a multidisciplinary center, and half are women (reflecting the over-sample of women in the design). The average respondent has been in a tenure track position for 15 years; as a result, 71% are tenured, and 46% are full professors. The average professor spends 7.66 h per week on grant writing and administration, 18.52 h per week on research, and 17.27 h per week teaching. The faculty collaborate with, on average, 5.48 other professionals, and supervise 4.21 graduate students. They spend 8.9 h per week on other types of service work. On a four point scale, they tend to be neutral as to whether they are paid what they are worth, somewhat more positive about being appreciated, and very positive about their job satisfaction. It should be remembered that the over-sampling of women drawn for this study makes it impossible to make inferences to parameters based on pooled means. We address this issue by comparing means of women and men, as each sample is representative of its respective gender group. Further, in our multivariate analysis we control for gender to evaluate the institutional effects, a strategy recommended by Winship and Radbill (1994).

Table 1 also provides a perspective on institutional and gender differences. The second two panels show *t*-test differences between the means of department-based and center-based professors, and between female and male professors. Significant differences in means at the 0.05 level or better are shown in bold. Considering first the mean differences by institutional setting (middle panel), we find there is no difference in demographic characteristics, career stage or in the service hours per week spent in professional service or paid consulting. Center-based researchers, however, spend more time on grant writing, conducting funded research, administering grants, collaborating with colleagues (with both men and women), and supervising graduate students (both men and women). These affiliated researchers spend less time than their department-based colleagues conducting unfunded research and teaching undergraduate students. Center-based scientists also feel more satisfied with their jobs, pay, and perceived appreciation. If research and graduate teaching are the plum assignments in the Research Extensive universities, then centers are superior to departments on every dimension.

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Table I
Means and standard deviations of research extensive scientists and engineers, by institutional setting and sex

	All scientists $n=1769$		Department based $n=1076$		Center based n = 693		Women $n=916$		Men $n=853$	
	M	SD	M	SD	M	SD	M	SD	M	SD
Demographic										
Nonwhite	0.18	0.38	0.19	0.39	0.16	0.36	**0.15**	**0.36**	**0.21**	**0.41**
Center affiliation	0.39	0.49	–	–	–	–	0.41	0.49	0.38	0.48
Female	0.52	0.5	0.5	0.5	0.46	0.5	–	–	–	–
Career event										
Tenure track year	1988.9	11.1	1988.5	11.48	1989.6	10.43	**1992.6**	**8.53**	**1985**	**12. 14**
Tenured	0.71	0.45	0.72	0.45	0.7	0.46	**0.63**	**0.48**	**0.79**	**0.4**
Full professor	0.46	0.5	0.45	0.5	0.49	0.5	**0.35**	**0.48**	**0.59**	**0.49**
Activity hours per week										
Writing grant proposals	5.12	5.83	**4.77**	**5.95**	**5.67**	**5.61**	**5.49**	**5.72**	**4.72**	**5.93**
Grant supported research	12.78	10.27	**11.67**	**9.99**	**14.49**	**10.47**	12.63	9.64	12.93	10.9
Unfunded research	5.74	7.89	**6.31**	**8.29**	**4.86**	**7.14**	**5.17**	**7.08**	**5.77**	**8.63**
Administering grants	2.54	3.57	**2.08**	**2.95**	**3.26**	**4.27**	2.64	3.86	2.43	3.23
Teaching										
Teaching undergraduates	10.46	9.42	**11.22**	**9.74**	**9.29**	**8.8**	10.87	9.28	10.03	9.57
Teaching graduate students	6.81	6.73	6.76	6.73	6.89	6.72	6.92	7.21	6.7	6.17
No. of female graduate students	1.46	2.04	**1.2**	**1.52**	**1.86**	**2.6**	**1.63**	**1.84**	**1.27**	**2.22**
No.of male graduate students	2.75	3.79	**2.35**	**3.15**	**3.38**	**4.54**	2.63	3.2	2.89	4.33
Service hours per week										
Professional service	2.73	3.8	2.73	3.87	2.72	3.68	2.79	3.77	2.66	3.83
University service	5.6	6.92	5.44	7.08	5.86	6.67	5.55	6.5	5.66	7.35
Paid consulting	0.57	1.78	0.55	1.73	0.61	1.87	**0.34**	**1.3**	**0.83**	**2.16**
Colleagues										
No. of female collaborators	1.27	1.91	**1.12**	**1.97**	**1.5**	**1.8**	**1.42**	**1.81**	**1.11**	**2.01**
No. of male collaborators	4.21	5.46	**3.75**	**5.65**	**4.93**	**5.07**	**4.45**	**5.91**	**3.95**	**4.92**
Colleagues appreciate me	2.86	0.83	**2.82**	**0.82**	**2.92**	**0.83**	**2.81**	**0.84**	**2.91**	**0.81**
I am satisfied with my job	3.15	0.83	**3.11**	**0.83**	**3.21**	**0.81**	**3.07**	**0.83**	**3.25**	**0.81**
I am paid what I am worth	2.55	0.94	**2.47**	**0.94**	**2.68**	**0.92**	2.52	0.95	2.59	0.93

We next examine mean differences between 916 female and 853 male scientists (right panel). Women are less likely to be of color, comprising only 15% of the female scientists and engineers. Women spend more time writing grant proposals, but less time working on unfunded research. Women also supervise more female graduate students, and collaborate more (with both male and female scholars). The female scientists in our sample are less satisfied with their jobs, and feel less appreciated by their colleagues for their research contributions. As expected, women are less likely to be tenured or full professors, the result of their younger career age. Men and women are equally likely to be affiliated with multidisciplinary research centers, about 40%.

Given the differences in the pattern of significant differences between center and department-based researchers, and male and female researchers, we also examine the dynamic role of gender and institutional setting on these constructs of interest. Table 2 presents the results of an ANOVA analysis of the 2*2 factorial design (center/noncenter; male/female) with interaction effects. Because the cells are unbalanced, we use general linear modeling (GLM) rather than a classic ANOVA estimation. The table reports the *F*-statistic associated with the total mean sum of squares (left panel). The remaining columns report the *F*-statistic associated with decomposing the total mean sum of squares into a direct gender effect (middle left panel), a direct institutional setting effect (middle right panel), and an interaction effect (right panel).

Looking first at the *F* statistic associated with the total mean sum of squares (left panel), we find that variation in almost all of the constructs is explained significantly by the inclusion of gender

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Table II
ANOVA analysis of 2*2 factorial design, with interaction effects

	Model		Direct: Gender		Direct: Institution		Interaction: gender*institution	
	F	Pr > *F*	*F*	Pr > *F*	F	Pr > *F*	*F*	Pr > *F*
Demographic								
Nonwhite	**4.91**	**0.002**	**10.63**	**0.001**	3.12	0.08	0.98	0.32
Career event								
Tenure track year	**78**	**0.0001**	**225.88**	**0.0001**	2.56	0.11	**5.55**	**0.02**
Tenured	**19.26**	**0.0001**	**56.29**	**0.0001**	0.15	0.7	1.33	0.25
Full professor	**37.08**	**0.0001**	**104.67**	**0.0001**	4.35	0.04	2.23	0.14
Activity hours per week								
Writing grant proposals	**5.95**	**0.0005**	**7.87**	**0.005**	**9.54**	**0.002**	0.45	0.5
Grant supported research	**11.64**	**0.0001**	0.39	0.53	**32.59**	**0.0001**	1.93	0.16
Unfunded research	**8.12**	**0.0001**	**9.91**	**0.002**	**13.77**	**0.0002**	0.68	0.41
Administering grants	**16.05**	**0.0001**	1.51	0.22	**46.55**	**0.0001**	0.07	0.79
Teaching								
Teaching undergraduates	**7.71**	**0.0001**	3.54	0.06	**18.17**	**0.0001**	1.41	0.23
Teaching graduate students	0.28	0.84	0.45	0.5	0.15	0.7	0.25	0.62
No. of female graduate students	**19.99**	**0.0001**	**13.92**	**0.0002**	**43.07**	**0.0001**	2.99	0.08
No. of male graduate students	**12.34**	**0.0001**	2.11	0.15	**32.62**	**0.0001**	2.31	0.13
Service hours per week								
Professional service	1.43	0.23	0.53	0.47	0.01	0.92	3.76	0.06
University service	0.79	0.5	0.11	0.74	1.57	0.21	0.7	0.4
Paid consulting	**11.6**	**0.0001**	**34.14**	**0.0001**	0.64	0.43	0.02	0.88
Colleagues								
No. of female collaborators	**9.54**	**0.0001**	**11.67**	**0.001**	**16.49**	**0.0001**	0.47	0.49
No. of male collaborators	**7.72**	**0.0001**	**3.8**	**0.05**	**19.24**	**0.0001**	0.11	0.74
Colleagues appreciate me	**6.61**	**0.0002**	**6.18**	**0.01**	**7.22**	**0.007**	**6.44**	**0.011**
I am satisfied with my job	**10.11**	**0.0001**	**22.08**	**0.0001**	**6.22**	**0.013**	2.02	0.16
I am paid what I am worth	**7.83**	**0.0001**	2.5	0.11	**20.7**	**0.0001**	0.31	0.58

and institutional setting. The only exception is hours of professional service and university service, in which there is no significant difference by either setting or gender. Looking at the decomposition of effects, we find a mix of direct effects, with few interaction effects. To explain all career event variables, the variance is explained by gender, and not by institutional setting. These are the only variables for which gender is the only explanation. Furthermore, there is an additional significant effect of being a center-based female on career age.

Variables for which the institutional setting is the only significant predictor are: grant supported research, administering grants, teaching undergraduates, number of male graduate students, and perceiving that one is paid what one is worth. Recall that center-based researchers do more grants activity, teach fewer undergraduates, and advise more graduate students than their department-based peers. These activities do not depend on the gender of the researcher.

For many variables, we find that gender and institution each have independent direct effects. This is true for writing grant proposals, conducting unfunded research, the number of female graduate students supervised, the number of professional collaborators, and level of job satisfaction. Our ability to predict these dependent variables is improved by the knowledge of both gender and institutional setting. There is only one significant interaction effect in the mixed models, that for feeling appreciated. Recalling again Table 1 (and using other results not shown), women as a group feel less appreciated by their colleagues, center-based researchers as a group feel more appreciated by their colleagues, and center-based women fall between these two groups in their level of feeling appreciated.

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Table III
Means and standard deviations of center-affiliated benefits by significant gender difference

	Center-affiliated $n=693$		Women $n=373$			Men $n=320$	
Variable	M	SD	M	SD	Sig.	M	SD
Opportunities for consulting	0.36	0.92	0.27	0.84	**	0.47	1.01
Opportunities for research grants or contracts from Industry	0.75	1.12	0.67	1.06	*	0.84	1.19
Ability to publish research that is more applied	0.77	1.09	0.85	1.12	*	0.68	1.05

No significant gender difference in perceived effects of center-affiliation: government contracts, journal publishing, interdisciplinary publishing, commercialization ability, research autonomy, proposal approval, collaboration, equipment, teaching load, tenure, students, or satisfaction. ***$p<0.001$; **$p<0.01$; *$p<0.05$.

On Tables 1 and 2, significant differences at the 0.05 level or better are depicted in bold.

Returning again to bivariate analysis, the benefits of center affiliation are generally enjoyed equally by both men and women. We found no significant gender differences in the perceived benefits of center-affiliation on the following constructs: government contracts, opportunity for journal or interdisciplinary publishing, commercialization opportunities, autonomy, proposal approval, access to students, collaboration opportunities, or equipment, teaching load, and prospects for tenure.

In Table 3 we show the three variables on which there is a significant difference between male and female center-affiliates. The women perceive fewer opportunities for industry-supported grants and contracts, and fewer consulting opportunities (a perception supported by women's significantly reduced participation in paid consulting irrespective of institutional setting). By contrast, the women perceive greater opportunities to publish applied research as a result of their center affiliation.

5. Discussion

Now we revisit our original hypotheses regarding the impacts of center affiliation on individual scientists.

We expected that centers would expose scientists to greater opportunities for research. This hypothesis was supported by the data. Center-based faculty spend significantly more time on

Table IV
Statement of hypotheses and results

Hypothesis	Result
(H1) Center-based scientists have access to more research resources than department-based scientists.	Hypothesis confirmed by data. Center-based faculty spend significantly more time writing grant proposals, conducting funded research, and administering grants.
(H2) Center-based scientists have more time for research relative to other academic obligations.	Hypothesis partially supported by data. University and professional service obligations for center-based and department-based faculty are not significantly different; however, center-based faculty have more graduate student teaching duties and fewer undergraduate student teaching duties.
(H3) Female scientists are more likely to be affiliated with university-based science centers.	Hypothesis rejected by data. Male and female scientists are equally likely to be affiliated with university-based centers.
(H4) Female scientists are more likely to be disadvantaged by carrying heavier service obligations because of their center participation.	Hypothesis partially supported by data. Male and female center-based faculty spend the same amount of time teaching graduate students and engaging in unpaid service activities; however, females spend slightly more time teaching undergraduates and less time on paid consulting.
(H5) Female scientists receive fewer individual benefits of their center affiliation (such as salary contribution, satisfaction with job, and feeling appreciated by colleagues).	Hypothesis partially supported by data. Even though center-based scientists of both genders do not differ when asked if they feel that they are paid what they are worth, male scientists are more satisfied with their jobs.

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writing grant proposals, conducting funded research, and administering grants. This was true for both men and women.

Our second hypothesis was that center-based scientists (of both genders) would have more time for research relative to other academic obligations. This hypothesis, however, was not fully supported by the data. University and professional service obligations for center-based and department-based faculty were not significantly different. Center-based researchers have heavier graduate student teaching duties, but department-based faculty spent more time on undergraduate teaching. In general, the data in this study demonstrate the center-based faculty have more research resources (and spend more time on research) than traditional, department-based scientists, but they also spend as much or more time on service obligations and teaching. In other words, it appears that center-based scientists have chosen to put in longer hours to reap the benefits of center affiliation.

We also hypothesized that women and men would experience different advantages from their center affiliations. In particular, we expected that women scientists would be more likely to be affiliated with university-based science centers, be more likely to be disadvantaged by carrying heavier service obligations because of their center participation, and receive fewer individual benefits of their center affiliation. First, we found that female scientists are as likely to be affiliated with a center as male academic scientists. Second, male and female center affiliates spend the same amount of time on (1) teaching graduate students, (2) professional and community service, and (3) university service. In addition, scientists of both genders supervised roughly the same number of male and female graduate students. The major discrepancies in service and teaching obligations for affiliated male and female scientists were related to teaching undergraduates (women spent 10.02 h per week on this activity while men spent 8.45) and paid consulting (men spent 0.86 h per week on this activity and women spent 0.39).

With respect to individual benefits of center affiliations, men and women are equally engaged in all facets of grant and research production. However, men are more likely to benefit from industry and consulting opportunities. Men feel slightly more satisfied with their jobs than center-based women do. However, center-affiliated male and female scientists do not differ when asked if they felt that they were paid what they are worth.

In summary, centers appear to perform an equalizing function with respect to those factors that facilitate the production of research, like grant writing and access to graduate students. Significantly, women do less paid consulting, and perceive fewer consulting and industrial opportunities than their center-affiliated male colleagues. To the extent that industrial opportunities create research production advantages, then women in centers enjoy more resources than their female colleagues, but fewer than their male colleagues. Furthermore, center-based women teach more undergraduate students than their male colleagues. Other bases of difference between men and women remain the same, irrespective of the institutional location of the scientist: men are older, more experienced, and more secure, and are generally more satisfied with their jobs.

6. Conclusion

The results of this research yield some positive news: university-based science centers could potentially serve as a leveling field for male and female academic researchers. Even though male and female center-affiliated scientists had busier work days (and spent more time working on grant writing) than their department-based colleagues, the center-affiliation provides a source of academic resources and recognition that elevates the female scientists to a research work environment similar to that of their male peers. We continue to be concerned about the gender difference in opportunities for consulting, and for industry support. If universities become more interdependent with industry, then women's lower access to industrial opportunities is worrisome.

This study is necessarily exploratory in nature; much explanatory work remains to be done. In particular, in further research we will introduce a longitudinal component using the curriculum vitae of half the scientists and engineers studied here. This will enable us to investigate sequencing and timing effects that cannot be studied in the cross-sectional design we employ here. We would like to investigate, for example, the temporal relationships among

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center affiliation timing, research productivity, and career progression. At this point, we do not know if center affiliation is the result of career progression and productivity, or whether it exerts independent effects on career velocity and productivity, or both—and under what conditions. We would like to investigate whether the nature of the center itself affects center benefits and disadvantages, and whether there are individual-level differences in the propensity to affiliate by type of center.

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