Academic Faculty Working in University Research Centers: Neither Capitalism's Slaves nor Teaching Fugitives

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This study addresses university-industry interactions for both educational and industrial outcomes. The results suggest that while academic faculty who are affiliated with centers are more involved with industry than non-affiliated faculty, affiliates are also more involved with and supportive of students at the undergraduate, graduate, and doctoral levels.

There has been quite a lot of study and discourse regarding the connection between universities and industry. The subtitle of our paper reflects our view of much of this literature—that it is rife with immoderation. Study of university-industry interactions is bifurcated, with some authors suggesting that these interactions are beneficial to economic development and technology transfer (e.g., Etzkowitz, 1998) and other authors characterizing the interactions as disruptive and potentially harmful to traditional university missions, especially to education (e.g., Slaughter & Rhoades, 2004). Really, the two perspectives constitute separate literatures. Seldom does empirical study of university involvement with industry address outcomes related to education, such as teaching and student support, and almost as a rule does the discourse on the potentially disruptive and harmful nature of university involvement with industry go unconcerned with the potential benefits of this involvement for education as well as for economic outcomes.

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Both views of university-industry interactions can be correct in isolation. Universities are complex and heterogeneous and thusly experience different outcomes from organizational innovation and institutional change. Doubtless, one can identify instances where university-industry interactions—owing either to their commercial nature or to any of a host of other differences with traditional academic activities and outcomes—have fractured the foundations upon which universities have been built. One can also find instances where university-industry interactions fit quite easily into the traditional university and its historic missions, enhancing rather than detracting from universities’ abilities to achieve public domain research, teaching, and service goals.

Connections between universities and industry in the United States can be traced back well over 100 years (Ruscio, 1984; Mowery & Ziedonis, 2002). But they have received much attention of late due to the establishment of new institutional forms on American campuses for governing university-industry interactions, specifically university research centers (URCs). The prevalence of URCs on American campuses is well documented (Dresser, 1989; Coburn, 1995). As policy mechanisms, URCs have attracted attention due to their pivotal roles in economic development and technology transfer. As organizations, they have attracted attention due to the divergence of their research missions from the discipline-based missions of traditional academic departments towards missions focused on addressing social and economic problems with science and technology (Boardman & Gray, 2010), conjointly between universities and industry—including the involvement of industry not only in university-based research and development but also in graduate education and training (Bozeman & Boardman, 2004).

While we expect a wide range of outcomes from the creation and institutionalization of URCs, our intuition and our previous research (e.g., Bozeman & Boardman, 2003; Boardman & Bozeman, 2007; Boardman, 2009) have led us to believe that the two dominant images of university-industry interactions are too stark and too focused on extreme cases to aptly characterize the impacts of URCs on academic faculty. It is understandable that those viewing URCs and their inhabitants as agents of technology commercialization focus on centers and programs that are compatible with these aims and that succeed in this mission. Similarly, those who see URCs and alternate arrangements for university-industry interaction as detrimental to traditional university missions will be able to find cases where they have had negative and disruptive outcomes.

Since we take it as axiomatic that new institutions such as URCs will have diverse outcomes, our concern in this study was with understanding the distribution of outcomes and the mechanisms affecting that dis-
tribution. Heretofore, representative data about URCs have not been available and, thus, the literature on URCs is dominated by case studies of single universities with multiple centers or of one or a few URCs. Owing to a lack of general data about the natural population of URCs, past research has tended to treat URCs and academic faculty working in them in an undifferentiated manner. Scholars have understood that there are considerable variations in URCs, but until now extant data did not permit charting that variation. Thus we expected some URCs to fulfill expectations of commercially-relevant outputs and economic benefits, other URCs to fulfill expectations from critics, but on the average for URCs to contribute to both the entrepreneurial and educational missions of U.S. universities.

Our study is one of the first to use data for a broad sample of URCs. We started with questionnaire data from a representative sample of U.S. academic researchers, focusing specifically on science, technology, engineering, and mathematics (STEM) faculty holding positions in Carnegie Foundation research extensive universities. Since in our administration of the survey we did not focus specifically on faculty who were center affiliates, we were able to ask whether or not respondents are affiliated with a URC to determine the percentage of academic researchers in the United States who are URC affiliates. Additionally, we were able to ask affiliated respondents to list the URC(s) with which they were affiliated to provide a representative sample of URC types, at least for the sampling population examined. From this sample of URCs, we created an ancillary data set tracking URC characteristics, including information about the size of the centers, the number of universities represented, and whether the centers were virtual or “bricks and mortar,” among other important factors.

The URC-level data supplement the questionnaires provided by university faculty and provide insight into the distribution of URC affiliates and URC types. These data permit us to address significant gaps in the literature. First, simply knowing more about the incidence of center membership and the distribution of center types proves useful from the standpoint of population ecology. Previous studies have examined well-known, high-profile URCs, especially those created in partnership with federal agencies. However, as we show here, these familiar, high-profile URCs are a relatively small minority of all URCs. Having an empirically-based typology of URCs permits us to examine membership in specific types of URCs and the effects of these specific types on academic researchers’ careers and work activities. This effort is abetted by the fact that our sample includes a majority of faculty who are quite similar to those affiliated with URCs but who are not themselves URC
affiliates. Thus, we are in the unique position of testing long-standing assumptions about the individual-level effects of URCs on universities.

We aimed our analysis at the two predominant characterizations of centers. We addressed the extent to which URC affiliation affects (1) the involvement of academic faculty with industry, such as the development and use of potentially commercial knowledge and technology and (2) faculty involvement with teaching and other student-related activities, including student support and mentoring.

Divergent Characterizations of Boundary-Spanning Universities and University Faculty

The study of universities and university faculty as boundary-spanning is itself boundary-spanning, including studies from higher education, sociology of science, research management, economics of innovation, and science and technology policy (Hagedoorn, Link, & Vonortas, 2000). Across these literatures, there has been some emphasis on URCs, but owing to the lack of general data for centers, a large proportion of research has been focused more broadly on the outcomes of university-industry interactions in any context.

There seems to be two divergent views of university faculty working with industry. The first perspective comes from the management and policy literatures, which has taken a relatively descriptive stance and generally has found university faculty to be involved with industry (Welsh, Glenn, Lacy, & Biscotti, 2008). These studies have focused on university patenting (Henderson, Jaffe, & Trajtenberg, 1998) and licensing (Thursby & Thursby, 2002), spin-off companies (Link & Scott, 2005), and faculty involvement with industry—ranging from informal information exchanges to consulting and employment arrangements between companies and faculty (Bozeman & Gaughan, 2007). The mechanisms emphasized in this body of work have included not only institutional design such as URCs but also national tax, subsidy, and intellectual property policies (Mowery, Nelson, Sampat, & Ziedonis, 2001), state-level policies and industry initiatives focused on regional economic development (Lee, 1996; Rogers, Takegami, & Yin, 2001; Lin & Bozeman, 2006), university characteristics (Ponomariov, 2008), and individual investigator grants and contracts (Bozeman & Gaughan, 2007). Studies focused specifically on URCs have shown affiliated faculty to be more likely than other faculty to collaborate with industry (Boardman & Corley, 2008).

The second perspective comes from the higher education and sociology of science literatures and essentially uses the industry involve-
ment of universities and university faculty, as evidenced in the management and policy literatures, as a platform for launching broad-based critiques of university-industry relations, including but not limited to URCs. Most notable among these critiques is the academic capitalism argument developed by Slaughter and Rhoades (1996) and Slaughter and Leslie (1997), which suggests that boundary-spanning organizations such as URCs detract from traditional educational missions and goals by inducing faculty to engage in market-like behaviors and therefore to shirk traditional research and educational activities for “more profitable” ones—or, at the very least, to harness traditional activities towards profitable ends (Slaughter, Campbell, Folleman, & Morgan, 2002). There are related studies that similarly have questioned how traditional university roles are compromised by URCs and university-industry interactions more generally (for examples, see Hackett, 2001, and Krinsky, 2003).

In our view, the extent to which the industry involvement of universities and university faculty affects the universities’ traditional research and educational missions remains a largely unanswered empirical question. Existing case studies are suggestive but not conclusive (Baldini, 2008). While university faculty may be more active participants in problem solving for and joint research with industry than suggested by Bush (1945) or even by Stokes’ (1997) characterization of use-inspired basic research, such activity does not necessitate a substitution of commercial research and related activities for the generation of new knowledge, the open publication of research in referred outlets, or for teaching and other activities related to universities’ educational missions and goals.

While the extent to which URCs affect faculty involvement with industry and students remains an open question, a handful of empirical studies inform our endeavor. A brief review of these works helps to bring focus both theoretically and empirically to our analysis.

The Relationship Between Industry Involvement and Publishing

The notion of university-industry interactions affecting academic faculty productivity does not originate with interest (positive or negative) in URCs. Though there has been but one direct analysis of this sort that we are aware of, albeit as a case study of a singular URC using panel data to demonstrate a positive impact of URC affiliation on the disciplinary and institutional diversity of faculty publication (Ponomariov & Boardman, 2010), there has long been a broader literature not focused on URCs per se— one anticipating and demonstrating more broadly a positive relationship between entrepreneurial outcomes such as uni-
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versity patenting and more traditional modes of dissemination such as publishing.

Studies of academic patenting and publishing have examined the extent to which university faculty are supplanting traditional academic research activities with market-like ones. Empirical assessments typically have shown either a positive (Meyer, 2006; Breschi, Lissoni, & Montobbio, 2005) or null (Agrawal & Henderson, 2002) correlation between the two dissemination modes. Relatively, university faculty who perform contractual work for industry are more prolific at publishing in peer-reviewed journals (Van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2004; Van Looy, Callaert, & Debackere, 2006). In terms of impact, the citation rates for publications authored jointly by academic and industry researchers are generally higher than are the rates for papers authored by university faculty alone (Hicks & Hamilton, 1999). Hence, there seems to be a complementary rather than substitutive relationship between industry involvement by faculty and traditional modes of academic research. Moreover, industry involvement seems to improve not just the research productivity of university faculty but also the quality or impact of their research (Baldini, 2008).

Examination of different dissemination modes and quality does not address the related concern over the substantive nature of academic research. The academic capitalist argument suggests that universities and university faculty are increasingly taking cues from industry in their valuation and selection of different avenues for research. Azoulay, Ding, and Stuart (2006), for example, provided some support for this concern by showing academic researchers in biotechnology to favor research questions that are commercially relevant. The agencies, such as the National Science Foundation (NSF) and National Institutes of Health (NIH), which have historically provided major funding for investigator-driven basic research, are increasingly emphasizing industry involvement in university science (Bozeman & Boardmann, 2004). Yet, those concerned with such movement in science and engineering fields have failed to demonstrate or explain how such a shift may be detrimental to the traditional research mission of universities. Industry has historically provided cues to university faculty for research and education (Mowery & Ziedonis, 2002), and some fields, such as the engineering disciplines and cross-disciplinary fields including biotechnology, are relatively applied and inherently “closer to market” than others.

In our view, the real concern lies not with new modes of dissemination, such as patenting, since such modes show generally to be complementary with publishing quantity and quality (Lin & Bozeman, 2006).
Nor do we feel concern should lie with new and commercially-relevant areas of research and development in universities, as university-industry relations are nothing new (Ruscio, 1984) and the accumulation of new knowledge necessarily forges university faculty into new institutional and epistemological realms (Corley, Boardman, & Bozeman 2006; Youtie, Libaers, & Bozeman, 2006). However, we agree that the concern should be the extent to which (in any way) these new modes and new areas of research and development undermine the educational missions of universities.

**The Relationship Between Research and Teaching**

The notion of university faculty shirking their educational responsibilities for research does not originate with URCs or the academic capitalist argument. Numerous commentaries on the traditional academic reward template, specifically its heavy focus on publications, have expressed concern over a tradeoff between research and teaching (Boyer, 1990; Braxton, 1996; Diamond, 1993, 1999). Accordingly, there has been considerable examination of the relationship between research and teaching, though none has addressed how different types of research and dissemination, such as those related to industry involvement and URC affiliation, may affect teaching differently.

The findings for this body of work are mixed. While some studies have observed a negative relationship between research and teaching (Cage, 1991; Massy & Zemsky, 1994), others have observed a positive relationship (Bowen & Schuster, 1986). There is perhaps the most empirical support for a null relationship (Braxton, 1996), with time allocated to research having no effect on time allocated to teaching and vice versa (Feldman, 1987). A meta-examination of these results provides some consistency, demonstrating particular university types to correspond with particular relationships (Milem, Berger, & Dey, 2000). Most relevant here are studies that have assessed samples of university faculty working in research extensive universities, which demonstrate a null relationship between teaching and research (Braxton, 1996).

In our view, these specific findings warrant further investigation into the extent to which the involvement of university faculty with industry affects their involvement with students, particularly for faculty affiliated with different types of URCs. Accordingly, in our analysis below we address the relationship between faculty involvement with URCs and their involvement with industry and students. Because our data are unique, we are uniquely in a position to distinguish among different types of URCs. Thus, we do not expect uniform levels of involvement with industry and students across all faculty center affiliates.
Data

Our data are from the NSF-funded Survey of Academic Researchers (SAR) conducted in 2004–2005 and extended in 2008–2009. The purpose of the survey was to study a variety of aspects of faculty work and attitudes in universities, focusing in particular on industrial activities and research-center affiliations. Our initial target population was tenured and tenure-track faculty members in Carnegie Foundation (2000) research extensive universities, Historically Black Colleges and Universities (HBCU), and universities designated as Experimental Program to Stimulate Competitive Research (EPSCoR). Sampling frames were constructed from university catalogs in the following National Science Foundation STEM disciplines: biology, computer science, mathematics, chemistry, physics, earth and atmospheric sciences, agriculture, and sociology. In addition, samples were drawn from five sub-disciplines of engineering: chemical, civil, electrical, materials, and mechanical.

Women were over-sampled from most disciplines. This was done to make sure that sufficient women appeared in the sample and, specifically, to ensure that women from every discipline would be represented, even those where women are found in quite small numbers (e.g., computer science, electrical engineering). Furthermore, stratification by sex replicates the tenure and rank distribution of fields, as women are likely to be at earlier career ages. The result of this stratification, of course, is that variables strongly correlated with sex may lead to spurious inference about co-varying variables. In the current study, all our statistical models control for gender, thus remediating this possible bias (Winship & Radbill, 1994). In a recent study (Bozeman & Gaughan, 2011), we used the alternative strategy of providing weights for all models but found negligible differences between a weighting strategy and controlling for gender.

The survey was sent to 5,916 targets, yielding 2,086 respondents after three waves of administration. Adjusting for deceased and retired targets, the effective response rate was 36%. The current study used a sub-sample of the initial survey, eliminating the HBCU and EPSCoR respondents as well as the sociology discipline. Each of these sub-strata was considerably less likely to be affiliated with URCs but, more important, we noted respondent selection bias for HBCU faculty as well as a considerably lower response rate (22%). The response rate for the current sub-sample of Carnegie Foundation research extensive faculty was 39.5%. For this group, we found no response bias based on discipline or rank. This particular analysis included 1714 respondents. Missing data
were a very small percentage (less than .1% of all observations) and appeared to be at random in sensitivity analyses.

The original SAR data included variables indicating whether respondents were affiliated with centers and the names of those centers. In the questionnaire, we provided a specific definition of a university research centers 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.” Following that definition, we asked respondents to check a box indicating that they were affiliated with a URC or another box indicating that they were not. If they were affiliated with more than one center, we asked them to indicate the affiliation they viewed as most important.

In a recent extension of the data, we set out to verify center membership. We did this in three ways. First, we examined websites for affiliate rosters. Second, we examined curricula vita for respondents (another part of the overall project involved collection of CVs from respondents; we did not use the CV data in this study). Finally, in a few cases, we either made telephone calls or sent emails to URC personnel to develop information about a variety of factors, including center membership.

Before providing hypotheses about the effects of URCs on industrial involvement and teaching and student-related activities, we begin by showing descriptive results for URC affiliation and center types.

Towards a Taxonomy of University Research Centers

Because there have been so few general assessments of URCs, examination of basic differences between different URCs is necessary before analyzing their impacts on faculty involvement with industry and students. We begin with a brief discussion of the URC coding scheme and then assess differences across the center types.

Coding the URCs

The first step in the coding process was to validate URC affiliation for SAR respondents. Whereas 632 respondents to the SAR indicated they were center affiliates, we were able to validate 500. Our analysis reflects only validated center affiliates.

The 132 not coded as valid center affiliates were dropped for several reasons. The most common disqualification was that respondents listed affiliations with research units not meeting our stipulated criteria for a URC (five or more faculty and postdoctoral students, participants from more than one discipline and more than one academic department). Our
objective was to get the best possible estimate, given the many vagaries associated with center affiliation.

In our URC coding protocol, senior investigators worked closely with graduate students to help classify URCs when the center type was not obvious. In some cases, there was little possibility for error. For example, the NSF and many other federal agencies provide lists of their centers. A center was designated as being associated with a particular federal agency not on the basis of the amount of funds provided via conventional grants but on the basis of formal affiliations, program competition awards, cooperative research agreements, and such. Some federal agency programs, including the NSF, have “sunset periods” after which direct funds are withdrawn and the center is expected to be self-sustaining. In the case of centers that had reached their “sunset period” with a federal agency, we listed them as “University” if the URC had continued with university-based funding. The greater difficulty was distinguishing between “State” and “University” URCs. The general rule was that if centers were created by state government with special program initiatives, such as “centers of excellence” programs, they were classified as “State.” Naturally, most of the public university URCs had at least some base state funding; absent some special designation or special program, these were coded as “University.”

Different Types of URCs

As Table 1 shows, three-fifths of the URCs in our study were created by universities and sustained by a combination of university base resources and individual investigator grant and foundation funds (and more rarely industry funds) that center affiliates typically bring in to support their research. Most of the literature on URCs has been less attentive to these types of centers, despite their numerical dominance. To the best of our knowledge, all case studies of URCs have focused on either federal- or state-established centers, particularly those established by the NSF. Other data-based studies of URCs have emphasized differences between government and industry centers (e.g., Boardman & Corley, 2008; Boardman, 2009) but have not addressed this dominant center type (at least in terms of raw numbers of URCs).

The second most common URCs in our study were ones created by the NSF under their various centers programs. There was no difficulty classifying the 81 NSF URCs, as they were on lists of centers and the NSF website, in most cases, provided clear information about the origins, sponsorship, and programmatic structure of the NSF centers. In addition, many of the programs of NSF centers have established their own program-wide websites, independent of the NSF, detailing past and
present centers, information on center characteristics, and best practices, among other resources.\textsuperscript{5}

The URCs we classified as “State” are generally those created by special programs from state government, often programs aimed specifically at engendering technology-based regional economic development. In comparison to the University URCs, these centers have been a much more common focus of research (Lee, 1996; Rogers, Takegami, & Yin, 2001; Lin & Bozeman, 2006), chiefly because of their explicit economic development and technology transfer missions.

The University, State, and NSF centers accounted for about 89% of the URCs in our data base, dominating the population of centers at Carnegie research extensive universities.\textsuperscript{6} Other URCs included in our study were sponsored by, among others, the National Institutes of Health (NIH), the Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), and the U.S. Department of Defense (USDOT). Many other agencies also sponsor URCs but not in sufficient numbers to ensure their presence in a large sample of university researchers.

**Empirical Differences Among the URC Types**

In light of the empirical evidence, developing a crude taxonomy presented no great challenge. Our basic taxonomy is four-fold: University, State, NSF, and Other. This is not entirely satisfying inasmuch as the

<table>
<thead>
<tr>
<th>Center Type</th>
<th>Number of Validated Center Affiliates</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>307</td>
</tr>
<tr>
<td>State</td>
<td>55</td>
</tr>
<tr>
<td>NSF</td>
<td>81</td>
</tr>
<tr>
<td>NIH</td>
<td>10</td>
</tr>
<tr>
<td>DOE</td>
<td>7</td>
</tr>
<tr>
<td>EPA</td>
<td>5</td>
</tr>
<tr>
<td>NASA</td>
<td>7</td>
</tr>
<tr>
<td>DOD</td>
<td>6</td>
</tr>
<tr>
<td>USDOT</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
</tr>
</tbody>
</table>
“Other” category lumps together quite disparate centers. We also understand that there may be considerable within-type variation. But even if the approach remains crude, it is important to remember that the Other category constitutes only about 10% of URCs in our study. When we speak of university faculty participating in URCs, we almost always refer to just three types: University, State, and NSF. This is a distortion of neither empirical reality nor history. The important question is whether a crude four-fold taxonomy can discriminate and predict behaviors.

We begin the analysis of the taxonomy by considering possible differences among the four types. Table 2 provides the means for the 500 centers included in our analysis according to number of affiliated faculty, founding year, and number of universities *formally* affiliated with the center. As we see from Table 2, the centers tended to be quite large with the average having about 68 faculty. Interestingly, the Other category tended to be largest in terms of faculty per center. This is perhaps not too surprising since almost all of these are sponsored by federal agencies, including the large centers created by the Department of Energy and Defense. The university-sponsored URCs, while most prevalent, were on average the smallest in terms of faculty per center.

On average, the NSF centers were of most recent origin. This is likely due, in part, to the fact that most NSF centers have “sunset” features and that they are also defunded on occasion prior to sunset. The State centers were the oldest and, one presumes, the most stable in their funding. Many State centers have a line item budget allocation. The NSF and State URCs have a larger number of cooperating universities. As one might expect, the State URCs often include multiple universities from within the sponsoring state. NSF URCs tend to link universities

<table>
<thead>
<tr>
<th>Center Type</th>
<th>Center Faculty</th>
<th>Year Center Founded</th>
<th>Number of Universities with Formal Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>54.9</td>
<td>1986</td>
<td>1.1</td>
</tr>
<tr>
<td>State</td>
<td>91.9</td>
<td>1976</td>
<td>3.1</td>
</tr>
<tr>
<td>NSF</td>
<td>67.3</td>
<td>1990</td>
<td>3.8</td>
</tr>
<tr>
<td>Other</td>
<td>112.1</td>
<td>1982</td>
<td>1.5</td>
</tr>
<tr>
<td>All</td>
<td>68.9</td>
<td>1985</td>
<td>1.8</td>
</tr>
</tbody>
</table>
that are geographically dispersed, partly because many of these centers are intended as national resources.

We were particularly interested in distinguishing “bricks and mortar” URCs from virtual ones. Literature on scientific communication leads one to expect quite different collaborative behaviors based on proximity and virtuality (Hinds & Kiesler, 1995; Iansiti, 1995; Bouty, 2000). The data presented in Table 3 show that University URCs are the ones most likely to be virtual, perhaps indicating a relatively modest investment in resources based on existing capabilities rather than new initiatives. The State centers are least likely to be virtual. This is perhaps owing to the fact that the State centers tend to be especially focused on a particular type of technology development and thus have applied missions requiring face-to-face interaction for their accomplishment.

With a basic understanding of the different types of URCs, we began our examination by assessing self-reports from URC faculty affiliates regarding the impacts of URCs, by URC type, on individual careers and productivity, including individual outcomes related to research, teaching, and commercial involvement.

**Descriptive Results for the Impacts of URC Affiliation on Faculty Involvement with Industry and Students**

Our chief concern was determining the impact of URC affiliation on faculty teaching-related activities and industrial interactions. We focused on these two outcomes because we felt that characterizations in previous research and commentary have been too stark and too focused on extreme cases. Since we had representative data for university STEM

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**TABLE 3**

Virtual and Not Virtual URCs, by Type

<table>
<thead>
<tr>
<th>Center Type</th>
<th>Not Virtual</th>
<th>Virtual</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>217</td>
<td>85 (28.1%)</td>
<td>302</td>
</tr>
<tr>
<td>State</td>
<td>49</td>
<td>5 (9.2%)</td>
<td>54</td>
</tr>
<tr>
<td>NSF</td>
<td>68</td>
<td>12 (15%)</td>
<td>80</td>
</tr>
<tr>
<td>Other</td>
<td>43</td>
<td>13 (23.2%)</td>
<td>56</td>
</tr>
</tbody>
</table>

*Note: Chi square = 12.97.*

*p<.005.*
faculty, with a close approximation in the percentages and composition of URC affiliates, our data permitted us to provide analysis of center impacts with a degree of confidence in the validity and generalizability of the findings. Overall, we expected URCs to affect the industry and student involvement of affiliated faculty, though not in the ways characterized by prior research focused on specific cases. Specifically, we expected certain types of URCs to have more impact than others. We begin with descriptive data for the industrial and student activities of URC-affiliated faculty. We reserve examination of the impacts of faculty affiliation with different types of URCs for the regression analyses in the following section.

**URC Affiliation and Faculty Industrial Activities**

The SAR questionnaire asked a branching question, first asking respondents if they had had any working relations with private companies during the past 12 months. While only 12% of respondents indicated they had industry funding through grants and contracts, more than half of respondents reported that they had had some type of industry interaction. These respondents were referred to a checklist to indicate the specific types of activities. Table 4 provides cross tabulations, showing the number and percentages of respondents engaged in various industrial activities, for both validated URC affiliates and non-affiliates.

The most apparent generalization we could make from these results is that URC affiliates seem to differ from others in that the affiliates are more likely to be involved in a wide range of industrially-relevant activity. For only one of the items, whether the respondent actually owned or worked for a company during the period of the survey, is there no statistically significant difference between URC affiliates and non-affiliates. This is likely due to the fact that so few in the sample answered “yes” on this item.

There is some difference among the items in terms of the degree of difference center affiliation seems to make. URC affiliates are twice as likely as non-affiliates to have coauthored a published paper with industry personnel and to have placed graduate students and postdoctoral students in industry jobs. URC affiliates are more than twice as likely to have served as a paid consultant to a private company.

Despite noteworthy and statistically significant differences between the two groups, it is important not to overemphasize differences. For every activity, both URC affiliates and non-affiliates were involved. Perhaps more important, for none of the activities was a clear majority engaged. With respect to the most commonly studied commercial activi-
ties, patenting, more than 90% in each group did not engage in patenting (at least during the year of the SAR survey).

Even the relatively modest level in industrial involvement depicted in Table 4 cannot be causally attributed to center affiliation. Since center affiliation is not a randomly distributed variable, unrelated to other characteristics of researchers, it is possible that some of the observed differences are owing to variables correlated with center affiliation. For example, engineers tend to be more involved with industry and are also overrepresented in URCs (at least in our sample). Moreover, in subsequent multivariate models, we control for field and several other possibly confounding variables in order to get a more valid assessment of URC effects.

### Table 4

Cross-Tabulations for Industry Involvement and URC Affiliation

<table>
<thead>
<tr>
<th>Industrial Involvement Activity*</th>
<th>Number and % Non-URC</th>
<th>Number and % URC</th>
<th>p valueb</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Persons from a private company asked for information about my research, and I provided it.”</td>
<td>372 (31.0%)</td>
<td>259 (50.3%)</td>
<td>0.000</td>
</tr>
<tr>
<td>“I contacted persons in industry asking about their research or research interests.”</td>
<td>187 (15.6%)</td>
<td>135 (26.2%)</td>
<td>0.000</td>
</tr>
<tr>
<td>“I served as a formal paid consultant to an industrial firm.”</td>
<td>192 (16.0%)</td>
<td>117 (37.9%)</td>
<td>0.002</td>
</tr>
<tr>
<td>“I helped place graduate students or post-docs in industry jobs.”</td>
<td>242 (20.2%)</td>
<td>186 (43.5%)</td>
<td>0.000</td>
</tr>
<tr>
<td>“I worked at a company with which I am owner, partner, or employee.”</td>
<td>36 (3.0%)</td>
<td>24 (4.7%)</td>
<td>0.115</td>
</tr>
<tr>
<td>“I worked directly with industry personnel in work that resulted in a patent or copyright.”</td>
<td>51 (4.3%)</td>
<td>42 (8.2%)</td>
<td>0.004</td>
</tr>
<tr>
<td>“I worked directly with industry personnel in an effort to transfer or commercialize technology or applied research.”</td>
<td>159 (13.3%)</td>
<td>114 (22.1%)</td>
<td>0.000</td>
</tr>
<tr>
<td>“I coauthored a paper with industry personnel that has been published in a journal or refereed proceedings.”</td>
<td>139 (11.6%)</td>
<td>115 (22.3%)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*a n = 1714 (1199 Non-URC-Affiliated, 515 URC-Affiliated).
b Based on Gamma coefficient.
**URC Affiliation and Faculty Teaching and Student Activities**

The SAR questionnaire includes a number of items for attitudes and behaviors related to faculty involvement with students. The attitudinal questions pertain to motives for collaborating and pursuing grants. The items for behaviors pertain to teaching graduates and undergraduates and student support. As with the descriptive results for industrial activities, we must treat the inferences from this initial examination with caution, as the results may be a function of inter-correlation with other causal factors that diminish the importance of URC affiliation.

**Student-Related Motives for Pursuing Grants and Research Collaborations.** One question in the SAR asks the following: “If you spend time writing or participating in the preparation of proposals for contracts or grants, please indicate your agreement or disagreement with the statements below,” all of which provide reasons for pursuing grants, including (among others) formal job requirements, administrative directives, intellectual pursuits, summer salary, and, relevant to our study, “a major motivation for my preparing proposals is to support graduate students.” The responses for the items use a Likert-type scale, including “Strongly Agree,” “Agree Somewhat,” “Disagree Somewhat,” and “Strongly Disagree.” The differences between URC affiliates and non-affiliates on the “support students” factor were statistically significant (Gamma 0.268, p< 0.000), with 94.1% of the URC affiliates agreeing (sum of “Strongly Agree and “Agree Somewhat”) and 87.7% of non-affiliates agreeing.

Another motivational survey item pertains to research collaboration. Respondents were asked to respond to this question: “If we define research collaboration as ‘working closely with others to produce new scientific knowledge or technology,’ how important is each of the following in factors in your decisions to collaborate?” Following the question was a wide variety of motivational choices (e.g., “delivers work in agreed upon time,” “chance to work with highly reputable researcher,” “researcher’s skills complement my own”), but the one most important for present purposes was “interest in helping graduate students.” (The Likert-type scale in this case was “Very Important,” “Somewhat Important,” “Somewhat Unimportant,” and “Not Important.”)

The URC affiliates and non-affiliates differed on this motivational variable, but the difference, while significant, was moderate (Gamma= 0.092, p<0.936). Among those not affiliated with URCs, 81.5% agreed that this was either somewhat important or very important; among the URC affiliates, 87.7% agreed.

Thus, in terms of magnitude, we observed but small differences between URC affiliates and non-affiliated faculty. What is notable, how-
ever, is that URC affiliation seemed to have a positive rather than negative impact on student-related attitudes and motives.

Teaching and Student Support. In addition to the motivational variables, we considered self-reports of teaching and other student-related activities. Table 5 provides tests for differences of means between URC affiliates and non-affiliates for time allocations to teaching and student advising and for the number of undergraduate students, master’s students, and doctoral students supported by respondents’ grants or contracts.

The general pattern was that university faculty not affiliated with URCs were more engaged teaching undergraduate students, spending on average more work hours in undergraduate teaching (10.5 hours per week on average) when compared to URC affiliates (8.5 hours per week). However, URC-affiliated faculty spent slightly more time teaching graduate students, but the difference is not statistically significant. The other major finding is that URC affiliates supported a larger number of students, not only doctoral students but also master’s students and undergraduates. The lesson seems to be that URC affiliation lessens undergraduate teaching but has the significant educational advantage of providing more financial support to students at every level.

| TABLE 5 |
| Means for Teaching-Related Activities, by URC Affiliation |

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>p value (F-Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Hours: Teaching Undergraduates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1197</td>
<td>10.51</td>
<td>8.18</td>
<td>0.012</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>512</td>
<td>8.50</td>
<td>7.74</td>
<td></td>
</tr>
<tr>
<td>Work Hours: Teaching Graduates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1196</td>
<td>6.26</td>
<td>6.33</td>
<td>n.s.</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>512</td>
<td>6.52</td>
<td>6.10</td>
<td></td>
</tr>
<tr>
<td>Work Hours: Advising</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1196</td>
<td>2.43</td>
<td>3.01</td>
<td>0.074</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>512</td>
<td>2.57</td>
<td>2.91</td>
<td></td>
</tr>
<tr>
<td># of Undergraduates Supported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1198</td>
<td>1.02</td>
<td>2.04</td>
<td>0.089</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>514</td>
<td>1.38</td>
<td>1.95</td>
<td></td>
</tr>
<tr>
<td># of Master’s Students Supported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1198</td>
<td>0.76</td>
<td>1.25</td>
<td>0.000</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>515</td>
<td>1.14</td>
<td>1.90</td>
<td></td>
</tr>
<tr>
<td># of Doctoral Students Supported</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (not URC)</td>
<td>1198</td>
<td>1.53</td>
<td>2.19</td>
<td>0.000</td>
</tr>
<tr>
<td>1 (URC)</td>
<td>515</td>
<td>3.00</td>
<td>2.89</td>
<td></td>
</tr>
</tbody>
</table>
Dependent Constructs and Hypotheses

Because there are so few general assessments of URCs, we based our hypotheses for URC affiliates’ industry and student involvement on our descriptive analysis above and on the relevant theories of research collaboration and faculty time allocations rather than on past results for centers based on single case studies or those studies using anecdotal evidence.

We had two sets of hypotheses about the impacts of URC affiliation, one pertaining to teaching impacts and the other to commercial impacts. Before presenting each set of hypotheses, we describe the relevant dependent constructs—for industry and student involvement, which include a variety of teaching- (e.g., time allocated by academic faculty to teaching, faculty support of graduate and undergraduate students) and commerce-related (e.g., different types and intensities of industry involvement) outcomes and activities.

URCs and Faculty Involvement with Industry

The Industrial Involvement Index. For commercial activities, we employed a scale developed previously (Bozeman & Gaugham, 2007), one that has by now been validated in a number of studies (e.g., Bozeman & Gaugham, 2011; Gaugham & Corley, 2010; Boardman, 2009; Ponomariov, 2008). The “Industrial Involvement Index” was created by examining the percentages for each of the industrial interaction items and then using the inverse as a weight. To give an example, 14.8% of this sample reported having coauthored a paper with someone from industry and, thus, engaging in that activity receives a weight of 85.2. Similarly, 6.2% of the sample reported having developed a patent with someone from industry and, thus, engaging in that more uncommon activity receives a weight of 93.8. The weights for all types of activities in which the respondents were engaged were then summed, creating a weighted Industrial Involvement Index. For the present sample, the index ranges between 0 and 6.68 with a mean of 1.27. The scale has the following properties: an alpha reliability of 0.78 and normal distribution (skew = 1.3; kurtosis = .99). It therefore meets the requirements for Ordinary Least Squares (OLS) Regression. Additional information about the scale is provided in Bozeman and Gaugham (2007), including results of an oblique (Oblimin) factor analysis used as an alternative, validating scale.

Hypotheses for URCs and Industry Involvement. We had two overarching hypotheses for the effects of affiliation with URCs on the industry involvement of faculty:
Hypothesis 1.1: Compared to faculty who are not affiliated with URCs, affiliated faculty will be no more (or less) involved with industry after controlling for variables mitigating the relationship between URC affiliation and industrial involvement.

Hypothesis 1.2: While overall there is no significant relationship between URC affiliation and industrial involvement, there will be modest differences in the industrial involvement when one takes into account URC type. Specifically, affiliation with NSF centers and State centers will increase industrial involvement.

It is not uncommon, as a matter of course, to posit the null hypothesis. However, our hypothesis of no effect was not simply a matter of form. Rather, we believed that most of the variance between URC affiliation and industrial involvement could be accounted for by two factors. First, only a small percentage of URCs have explicit industrial outreach and commercialization missions, specifically the NSF and State URCs. Examining the representative list of URCs in our data set, the rest are relatively small institutions focused on creating fundamental knowledge in the sciences. Thus, in our expectations for faculty industry involvement, we followed both the institutional (Clark, 1998) and resource-based views (e.g., Barney, 1991; Grant, 1996) of research collaboration by positing a positive effect for only certain types of URCs. While NSF and State URCs are likely to have the knowledge-integration and capacity-development motives conducive to institutional norms and expectations for industry involvement by affiliated faculty, the other center types are likely to harbor motives and norms towards traditional academic research and related activities.

Second, we know from case studies that engineering faculty tend to be overrepresented in URCs and that engineering faculty generally are much more likely, whether or not they are associated with URCs, to be involved with industry (see, for example, Bozeman & Boardman, 2003; Boardman & Bozeman, 2007). Engineering and other disciplines are important controls, as different disciplines have properties that result in variable propensities for industry involvement. For instance, some disciplines require broader skill sets and access to diverse resources (van Rijnsoever, Hessels, & Vandeberg, 2008), which may be gained by expanded professional ties and network linkages (Bozeman, Dietz, & Gaughan 2001), including but not limited to industry.

We also controlled for other variables possibly confounding the relationship between URC affiliation and industrial involvement, including tenure, age, U.S. citizenship, and gender. We expected that those who
are older and tenured would be more likely to be involved with industry; our reasoning is that industrial activities generally do not contribute much in tenure decisions and, thus, those in tenure jeopardy will tend to focus more time on traditional (non-commercial) academic research (van Rijnsoever, Hessels, & Vandeberg, 2008; Boardman & Ponomariov, 2007). With regard to U.S. citizenship, we expected that this is to some extent an indicator of English language fluency and that industry, all else equal, prefers to avoid communication barriers. Naturally, we understand that many non-citizens are fluent, but compared to citizens, many fewer are fluent. U.S. citizenship may also be a proxy for social capital and for “insider knowledge” about how to deal with the university and business bureaucracies that buffer relationships between faculty and industry (Lee & Bozeman, 2005). Finally, we controlled for gender because we know from other research using this data that women, both those who are URC affiliates and others, tend to be less likely involved with industry and also because our data over-sampled women and such a control, to some extent, remediates the over-sampling (see Corley & Gaughan, 2005, for discussion of both points).

**URCs and Faculty Involvement with Students**

**The Student Involvement Indices.** As was the case with the industrial involvement variables, it was useful to develop multivariate indices so as to vitiate the need for a large number of separate regression models. In this case, we developed “Student Involvement Indices” based on a factor analysis of the two motivational and six items discussed in the descriptive analysis above. Specifically, we employed a principal components analysis, using Varimax rotation to ensure optimal loading of variables on the dimensions. Table 6 provides the results of the analysis. As is customary, we named the resultant factor dimensions according to the variables with the highest magnitude loadings for the respective factors. The first factor dimension we termed “Students Supported” because all three loadings in excess of +/- .50 pertained to the number of students supported. The second Student Involvement Index, “Mentor Motivation,” includes high loadings on the two motivation variables, the motive to seek grants to support students and the motive to collaborate on research to help graduate students. The third Index was termed “Teaching Undergraduates” because the strongest positive loading was percentage of time teaching undergraduates; teaching graduate students loads strongly but negative on the dimension.

It is useful to note that the three factors range in their eigenvalues from 1.09 to 1.83, indicating that no factor is dominant and that none is a spurious or shadow factor (Green, 1983). Furthermore, let us note that
TABLE 6
Factor Analysis of Student Impact Variables

<table>
<thead>
<tr>
<th>Factor Loadings</th>
<th>“Students Supported”</th>
<th>“Mentor Motivation”</th>
<th>“Teaching Undergraduates”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants: Support Graduate Students</td>
<td>0.176</td>
<td>0.687</td>
<td>0.256</td>
</tr>
<tr>
<td># of Undergraduates Supported</td>
<td>0.799</td>
<td>-0.070</td>
<td>-0.149</td>
</tr>
<tr>
<td># of Master’s Students Supported</td>
<td>0.659</td>
<td>0.101</td>
<td>0.044</td>
</tr>
<tr>
<td># of Doctoral Students Supported</td>
<td>0.624</td>
<td>0.142</td>
<td>0.186</td>
</tr>
<tr>
<td>Collaboration: Help Graduate Students</td>
<td>0.058</td>
<td>0.783</td>
<td>0.075</td>
</tr>
<tr>
<td>% time on all advising</td>
<td>-0.020</td>
<td>0.468</td>
<td>-0.247</td>
</tr>
<tr>
<td>% time on undergraduate teaching</td>
<td>-0.177</td>
<td>-0.096</td>
<td>-0.734</td>
</tr>
<tr>
<td>% time on graduate teaching</td>
<td>-0.101</td>
<td>-0.031</td>
<td>0.773</td>
</tr>
</tbody>
</table>

Note: Specifications: (a) Extraction Method: Principal Component Analysis; (b) Rotation Method: Varimax with Kaiser Normalization; (c) Eigenvalues: “Students Supported” (1.83), “Mentor Motivation” (1.27), “Teaching Undergraduates” (1.09).

each of the factors is an interval scale variable and, thus, can be used as a dependent variable in an OLS regression model.

**Hypotheses for URCs and Student Involvement.** Whereas we expected URC affiliation to have only modest overall effects on industry involvement, we expected greater effects on certain aspects of student involvement:

Hypothesis 2.1: Compared to faculty who are not affiliated with URCs, affiliated faculty will, in general, be more involved with students per the “Students Supported” index, after controlling for variables mitigating the relationship between URC affiliation and student involvement.

Hypothesis 2.2: Compared to faculty who are not affiliated with URCs, affiliated faculty will, in general, be more involved with students per the “Mentor Motivation” index, after controlling for variables mitigating the relationship between URC affiliation and student involvement.

Hypothesis 2.3: Compared to faculty who are not affiliated with URCs, affiliated faculty will, in general, be less involved with undergraduate students and more involved with graduate students per the “Teaching Undergraduates” index, after controlling for variables mitigating the relationship between URC affiliation and student involvement.
Except for the expectation for teaching undergraduates, the hypotheses for the Student Involvement Indices run counter to characterizations of URCs having a negative impact on faculty involvement with students. Since URCs typically are holding institutions for new or discretionary resources and since students are often an important part of the research production mission common to all URCs, it stands to reason that URC affiliates would have at least some student support resources beyond those available to non-affiliated faculty. This general expectation is supported by previous case study and empirical research on URC faculty teaching and student interactions (e.g., Corley & Gaughan, 2005; Bozeman & Gaughan, 2011). Moreover, some of the URC types in the taxonomy presented above have explicit educational missions, including the center programs at the NSF (Bozeman & Boardman, 2004).

Ponomariov (2009) has provided not only the most general empirical support (and therefore the strongest evidence) of a positive relationship between university-industry interactions and student outcomes at the faculty level of analysis, and controlling for URC affiliation at that, but also a compelling explanation of the positive relationship in terms of cumulative advantage (albeit at the individual faculty rather than the university level of analysis). Specifically, Ponomariov explained students as an important dimension of academic researchers’ human and social capital that is particularly suitable for the work that characterizes many university-industry interactions, in URCs as well as in other contexts and arrangements.

It is important to note that our general expectation of a positive effect was for graduate students. In contrast, we expected that URCs may have a negative impact on faculty involvement with students in situations when faculty research may be less integrated with students, for instance when teaching undergraduates. However, if prior empirical findings on the relationship between faculty time allocated to research versus that allocated to teaching is to serve as a guide, we know that for faculty in Carnegie Foundation research extensive universities (from which the SAR sample was drawn) generally a null relationship is found (Feldman, 1987; Braxton, 1996; Milem, Berger, & Dey, 2000; Link, Swann, & Bozeman, 2008).

As with our expectations for the Industry Involvement Index, we expected that a number of individual factors besides URC affiliation would explain variability in faculty student involvement. For instance, tenured faculty may be more likely involved with teaching graduate than undergraduate courses, which is true for many departments in research extensive universities—the latter being taught by junior faculty and adjuncts. Thus, while we had some expectation of a negative rela-
tionship between URC affiliation and student involvement (i.e., teaching undergraduate students), this expectation was tentative.

Our general expectation of a complementary rather than substitutiv relationship between URC affiliation and student involvement was not the result of optimism or other positive attitudes towards URCs developed during our past research on the topic. Indeed, much of our work on centers has examined the problems that affiliation poses for faculty (e.g., Bozeman & Boardman, 2003; Boardman & Bozeman, 2007).

Considering that many URCs have explicit educational missions, we expected a positive connection not just between URC affiliation and student support but also between affiliation and teaching. This latter relationship (between URCs and teaching) has received the least attention in past empirical study and constitutes perhaps the most important component of our analysis. While a positive correlation between URC affiliation and student support may still be interpreted “negatively”—as academic faculty capitalizing on students to ensure their own profit in terms of grants and contracts procured from government and industry⁸—finding a tandem positive correlation between URC affiliation and teaching will mitigate such an interpretation.

Regression Results

**URCs and the Industry Involvement Index**

Table 7 provides the results for an OLS regression model for the Industrial Involvement Index on the center taxonomy dummies as well as on controls for scientific field (engineering is the reference), tenure (untenured is the reference), gender (female is the reference), age, and U.S. born (non-native is the reference). The results show that the model explains about 16% of the variance in the Industrial Involvement Index (adjusted R² = 0.165) and that each of the URC taxonomy variables is statistically significant. As we anticipated, the type of URC with which one is affiliated does make a difference. While each of the beta coefficients is significant and positive, the University-sponsored center is most strongly predictive of industry involvement and the State centers (0.052) the least. The more important story is perhaps the one told by examining the results for field. While the engineering field variable is excluded from the model owing to collinearity tolerances, each of the included fields is significantly and negatively associated with industrial involvement, indicating that relations between URC affiliation and industrial involvement, while significant, are eclipsed by field effects. The implication is that while URC affiliation appears to increase industry
### TABLE 7
Regression Results for the Industry Involvement and Student Involvement Indices

<table>
<thead>
<tr>
<th></th>
<th>(1) Industry Involvement</th>
<th>(2) Students Supported</th>
<th>(3) Mentor Motivation</th>
<th>(4) Teaching Undergraduates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstandardized Coefficients</td>
<td>Standardized Coefficients</td>
<td>Unstandardized Coefficients</td>
<td>Standardized Coefficients</td>
</tr>
<tr>
<td>1 if ever tenured</td>
<td>0.434** (0.086)</td>
<td>0.137</td>
<td>0.450** (0.062)</td>
<td>0.203</td>
</tr>
<tr>
<td>Gender</td>
<td>0.302** (0.070)</td>
<td>0.105</td>
<td>0.010</td>
<td>0.005</td>
</tr>
<tr>
<td>1 = Male, 0 = Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native-Born U.S. Citizen</td>
<td>0.164* (0.075)</td>
<td>0.052</td>
<td>0.096</td>
<td>0.043</td>
</tr>
<tr>
<td>Age in years</td>
<td>-0.008* (0.004)</td>
<td>-0.057</td>
<td>-0.015** (0.003)</td>
<td>-0.154</td>
</tr>
<tr>
<td>Biology or agriculture</td>
<td>-0.653** (0.100)</td>
<td>-0.167</td>
<td>-0.075</td>
<td>-0.027</td>
</tr>
<tr>
<td>Math or computer scientist</td>
<td>-0.790** (0.101)</td>
<td>-0.197</td>
<td>-0.202</td>
<td>-0.070</td>
</tr>
<tr>
<td>Physicist or chemist</td>
<td>-1.104** (0.083)</td>
<td>-0.346</td>
<td>-0.069</td>
<td>-0.031</td>
</tr>
<tr>
<td>Engineer*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University-Sponsored Center</td>
<td>0.372** (0.086)</td>
<td>0.102</td>
<td>0.325** (0.063)</td>
<td>0.126</td>
</tr>
</tbody>
</table>

(continued)
TABLE 7 (continued)
Regression Results for the Industry Involvement and Student Involvement Indices

<table>
<thead>
<tr>
<th></th>
<th>(1) Industry Involvement</th>
<th>(2) Students Supported</th>
<th>(3) Mentor Motivation</th>
<th>(4) Teaching Undergraduates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstandardized Coefficients</td>
<td>Standardized Coefficients</td>
<td>Unstandardized Coefficients</td>
<td>Standardized Coefficients</td>
</tr>
<tr>
<td>State-Sponsored Center</td>
<td>0.430*</td>
<td>0.052</td>
<td>0.140</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>(0.192)</td>
<td>(0.139)</td>
<td>(0.143)</td>
<td>(0.145)</td>
</tr>
<tr>
<td>NSF-Sponsored Center</td>
<td>0.528**</td>
<td>0.079</td>
<td>0.435*</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.117)</td>
<td>(0.120)</td>
<td>(0.122)</td>
</tr>
<tr>
<td>Other Federal-Sponsored Centers</td>
<td>0.558**</td>
<td>0.073</td>
<td>0.518**</td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td>(0.178)</td>
<td>(0.134)</td>
<td>(0.138)</td>
<td>(0.139)</td>
</tr>
<tr>
<td>(Constant)</td>
<td>1.284</td>
<td>0.153</td>
<td>-0.326</td>
<td>-0.108</td>
</tr>
<tr>
<td>Observations</td>
<td>1564</td>
<td>1532</td>
<td>1532</td>
<td>1532</td>
</tr>
<tr>
<td>Adjusted R squared</td>
<td>0.165</td>
<td>0.119</td>
<td>0.065</td>
<td>0.037</td>
</tr>
</tbody>
</table>

Note. Robust standard errors in parentheses.
* Excluded variable: Engineer (Tolerance .000)
* Significant at 5%. ** Significant at 1% or better.
involvement, the overrepresentation of engineers in URCs may be the more important characteristic.

**URCs and the Students Supported Index**

Table 7 also gives the results for the Student Involvement Indices, the first of which is the “Students Supported” Index. The standardized beta coefficients for affiliation with URCs in the University, NSF, and Other categories are positive and significant. The findings for State-sponsored URCs, while in a modestly positive direction, are not statistically significant. We speculated that these State URCs tend to have less reliance on federal grants and, as a result, less external funding for support of students. Also they are somewhat more likely to be commercially focused and, thus, students may play a lesser “production” role than in centers more focused on fundamental or pre-commercial research.

While the URC variables were our chief interest, the model’s results offer other potentially interesting findings. As with the findings for industry involvement, engineers are more likely to support students than are faculty in other fields. This finding, which is in accord with previous studies with a different but comparable database (Lin & Bozeman, 2006), is not surprising for at least two reasons. First, the largest and best-funded URCs (e.g., the NSF centers), which tend to have educational missions, also tend to have a disproportionate percentage of engineers. Second, engineers tend to be considerably more active in supporting master’s students and no less active in supporting doctoral students (Lin & Bozeman, 2006; Bozeman & Gaughan, 2007).

Unexpectedly, age is negatively related with student support, but tenure is (as expected) positively related. After checking frequencies, differences of means, and zero order correlations, we observed that these findings are valid ones. A scan of the original data suggests that the relationship is curvilinear with the youngest respondents and the oldest respondents supporting fewer students. But since the curve of student support and age is steeper at the front end of the age distribution than in the back end, the beta for linear regression is as we have observed.

**URCs and the Mentor Motivation Index**

The model for a second Student Involvement Index, “Mentor Motivation,” is not well accounted for by URC affiliation of any type. Table 7 shows that one’s affiliation with a URC does not seem to affect student-oriented motivation for grant support or research collaboration. Instead, the modest amount of variance explained in this model is best accounted for by tenure status, with tenured persons having a positive association with the “mentor” dimension and, by field, with engineers
and physicists/chemists more likely to have a positive association with the dimension.

**URCs and the Teaching Undergraduates Index**

Finally, Table 7 shows the results for the last Student Involvement Index, “Teaching Undergraduates,” to be more robust. Among the URC types, only affiliation with NSF centers does not have a positive association with the teaching dimension, implying not only that faculty in NSF centers spend less time teaching undergraduates but also that these URC affiliates spend more time teaching graduate students. The State-sponsored centers have the strongest association with the dimension. As with the findings for the Students Supported Index, this may be due to a somewhat lesser degree of dependence by these centers on federal grants and, as a result, less funds available for teaching buyout.

The finding that native-born U.S. citizens have a negative relationship to teaching undergraduates is possibly explained by the measure of the key variables in the dimension. The teaching items did not ask how many courses are taught or how many students but how much time is spent on teaching. Since a majority of the non-native U.S. citizens do not speak English as a first language, it is at least possible that more preparation time is required of them. Another possibility is that native English speakers are more adept at obtaining grants and teaching buyout and that they prefer to buy out of undergraduate classes.

**Discussion and Conclusions**

Given our dual interest in the effects of URCs on both the industry and student involvement of faculty affiliates, the regression results are most appropriately discussed collectively. To discuss each individually does not exclude necessarily the assumptions and interpretations found in prior research and commentary—specifically those from the academic capitalist literature that industry involvement by faculty necessitates either a tradeoff with student involvement or somehow alters faculty involvement with students towards “profitable” ends—that we avoid by empirically addressing both industry- and student-related outcomes for URC affiliates.

By themselves the regression results for industry involvement may give the impression that URC affiliates are indeed “capitalism’s slaves,” since respondents to our survey affiliated with each URC type have higher scores on the Industry Involvement Index when compared to their non-affiliated counterparts. However, even limiting interpretation to this single model, this “capitalism’s slaves” conclusion is quite a leap
from the empirical results. The relative effects of the URC affiliation on industry involvement were quite small when compared to the scientific and engineering field effects and also when compared to the effect of tenure status. Thus, to the extent that one may use these findings to characterize URC affiliates as beholden to market demands, so must senior faculty and engineers be characterized. The appropriate conclusion to draw from this single model is that on average all university faculty are involved with industry at some level and that URC affiliates are only slightly more involved, at least for a representative sample of faculty in Carnegie research extensive universities.

The results do not show academic researchers as necessarily beholden to market demands at the expense of universities’ traditional research and educational missions, which is the predominant concern behind the academic capitalist critique. Interpreting the results for student involvement in light of those for industry involvement, we know that center affiliation does not result in faculty flight from students and, importantly, from teaching. Rather, the regression findings show that the same URC affiliates who are somewhat more involved with industry than non-affiliated faculty are also more likely to support both undergraduate and graduate students. While this may be interpreted as students being dealt as “tokens of exchange” (Slaughter, Campbell, Folleman, & Morgan, 2002) from faculty to industry, such an interpretation of faculty motives is called into serious question when one additionally considers that URC affiliates are also more involved with teaching undergraduates—perhaps the educational activity with the least opportunity for faculty “profit.”

We do not wish to overstate our findings. While the nightmare scenarios, those seeing URCs as fundamentally undermining the traditional missions of universities, obtain no support from the data presented here, this is not to say that such scenarios do not exist. Ours is an aggregate analysis, and case studies suggest a range of possible outcomes. We do not wish to imply that URCs are an unalloyed benefit for education, and we have no doubt that there are circumstances where URC affiliates are torn in multiple directions, resulting in less attention to teaching, regardless of the teaching load (see Boardman & Bozeman, 2007). This variability in the unintended effects of URCs, we believe, has to do variability at the center level. One of the chief themes of this paper has been that not all URC types are the same and that being a center affiliate may have different meaning depending on the type of URC. Whether or not our assessment of the differences between URCs is the correct one, we have made clear that URCs are not homogenous and much remains to be learned by developing a deeper knowledge of their differences. In particular, the pervasive notion that URCs are centers for academic
commerce seems clearly overstated. Most URCs and the faculty performing research in URCs are oriented to traditional, public domain, research publications. Academic capitalism merits study not because it is the norm but because of its exceptionalism.

Notes

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1 Or we referred to departmental web pages if the university catalog was not available online.

2 Generally, these respondents reported affiliations with laboratories supported by a single academic department. In a few cases, respondents reported affiliations with qualifying URCs but for periods in which the respondents were graduate students or postdoctoral researchers (we focused only on faculty affiliates). In addition to these factors, it is likely (though we have no direct evidence) that some discrepancy is due to the fact that “center affiliation,” a seemingly discrete behavior, is not a clear-cut phenomenon. Whereas reporting that one is, say, an assistant professor, has formal meaning and is based ultimately on formal documents, center affiliation is rarely so formal. At many centers, there are several layers of involvement ranging from name-only to day-to-day activity and interaction.

3 On those occasions where it did not seem clear, even after some considerable investigation as to whether a URC should be classed “State” or “University,” we telephoned or wrote emails asking for clarification. All those with whom we communicated (usually center directors or their administrative staff) responded.


6 We feel this set is a good approximation of our URC sampling population. However, there is one artifact of the sampling population that renders it an imperfect indicator of the entire population of URCs. Since we did not include medical faculty and medical schools in our STEM sample, we have underestimated NIH centers. However, the NIH began its centers programs relatively late compared to many of the federal agencies represented in Table 1, and thus it is likely that the underrepresentation is a modest one. Today, NIH has 27 intramural centers and institutes, and these remain a stronger focus than university-based centers (National Institutes of Health, 2009). Examining the P50 classification center awards from NIH leads us to believe that NIH represents about 3–4% of all URCs.
Among the 1714 respondents in the sample, 23 reported they were not involved in pursuing grants and contracts. These individuals are treated as missing data for this variable.

The wording, though, of the grants and collaboration motivation items discussed above for the Student Involvement Indices strongly imply that students are the motivation to pursue grants and collaborators, not the other way around.

References


