

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/236800411>

Role Strain in University Research Centers

Article *in* The Journal of Higher Education · July 2007

Impact Factor: 1.15 · DOI: 10.1353/jhe.2007.0020

CITATIONS

65

READS

87

2 authors:



[Craig Boardman](#)

38 PUBLICATIONS 697 CITATIONS

[SEE PROFILE](#)



[Barry Bozeman](#)

Arizona State University

333 PUBLICATIONS 7,421 CITATIONS

[SEE PROFILE](#)



PROJECT MUSE®

Role Strain in University Research Centers

Craig Boardman, Barry Bozeman

The Journal of Higher Education, Volume 78, Number 4, July/August 2007, pp. 430-463 (Article)

Published by The Ohio State University Press
DOI: 10.1353/jhe.2007.0020



➔ For additional information about this article

<http://muse.jhu.edu/journals/jhe/summary/v078/78.4boardman.html>

Role Strain in University Research Centers

Introduction

Over the past three decades, research in the sciences and engineering has become increasingly multidisciplinary, requiring intellectually diverse groups to answer complex research questions. As a result, research collaborations that span organizations and institutions have become a common means through which policymakers and public officials seek to accomplish goals related to generating and deploying scientific and technical knowledge. Indeed, this period in U.S. science and technology policy could be credibly deemed the “era of interinstitutional research collaboration,” notably in light of the emergence of university research centers—university-based research organizations focusing on research topics rather than disciplines that implement strong interinstitutional and cross-sector ties, often funded by federal monies and supporting scientists from industry as well as from other universities (Bozeman & Boardman, 2003).¹

The titles of recent studies of academic science suggest the dynamic and disruptive nature of universities’ changes in institutional design. Etzkowitz, Webster, Gebhardt, and Cantisano Terra (2000) examine the “evolution of the ivory tower to entrepreneurial paradigm”; Slaughter, Campbell, Folleman, and Morgan speak of “trafficking” in graduate students and examine “graduate students as tokens of exchange between

Craig Boardman is research staff member at the Science and Technology Policy Institute, Washington, DC. Barry Bozeman is Ander Crenshaw Chair and Regents’ Professor of Public Policy at the University of Georgia.

The Journal of Higher Education, Vol. 78, No. 4 (July/August 2007)
Copyright © 2007 by The Ohio State University

academe and industry” (2002, p. 294); Owen-Smith (2003) provides what is perhaps the most useful tag, noting the movement of universities and industry “from separate systems to hybrid order,” with the distribution of knowledge produced by academic science no longer conforming to public goods norms and expectations.

When institutions change rapidly, the lives of the actors within them typically become more complex and sometimes more difficult. One way in which university faculty members’ professional lives have become more complex with the advent of contemporary university research centers is that many faculty have taken on additional roles. Indeed, multiple roles was a *requirement* at the inception of the National Science Foundation’s Engineering Research Centers and Science and Technology Centers program, the programs that have become in many respects the template for complex, multifunction, multidiscipline university research centers. According to Erich Bloch, the NSF director during the time the centers programs were created, these programs began with the assumption that all centers affiliates would be full-time, tenured or tenure-track faculty who had appointments in academic line departments—thus assuring multiple responsibilities and enhancing the likelihood of role strain (Bozeman & Boardman, 2004).

Our concern in this article is to determine the extent to which role strain is experienced by university faculty members who are affiliated with a university research center but who have academic appointments in university departments. Who experiences the role strain, and to what degree? Why do faculty, knowing the multiple and perhaps conflicting demands of multiple allegiance, affiliate with university research centers? What strategies do they develop to cope with role strain?

Our study is based on intensive interviews with 21 academic scientists and engineers affiliated with either NSF Engineering Research Centers (ERC) or Science and Technology Centers (STC) as well as with traditional academic departments.² The NSF centers are of especial interest not only because they require a tenure-eligible appointment in an academic department or program but also because they are among the most complex of university research centers. Whereas most university research centers are relatively simple in structure (Gaughan & Bozeman, 2005), these NSF centers qualify as “multipurpose, multidiscipline university research centers,” or MMURCs (Bozeman & Boardman, 2003). The MMURCs, almost all of which have a history of less than 25 years, retain as their distinctive characteristics: (a) the mixing of disciplines and scientific fields; (b) extensive interaction with institutions external to the university, including private companies as well as other universities; and (c) a blending of diverse research

missions with outreach, including technology transfer or technical assistance.³ Research suggests that the MMURCs and the academic departments tend to have quite different reward and incentive systems (see Geisler, 1989).

Our theoretical approach draws from role theory and particularly concepts pertaining to role strain, as initially developed by Merton (1957a, 1957b), Goode (1960), and Kahn, Wolfe, Quinn, Snoek, and Rosenthal (1964). Although role theory is nearly 50 years old and seems especially relevant to the complexities of scientific careers, it has received surprisingly little attention from researchers of scientists' values and behaviors. The most familiar application of role theory to scientific work was that of Box and Cotgrove (1966), who focused on industrial scientists.

Before proceeding with our analysis, let us consider why it might be important to focus on role strain among those affiliated with university research centers and academic departments (we return to this issue in our conclusions). First, role strain *within* academic departments, concerning teaching and other nonresearch tasks in addition to scientific work, is already a chief concern (Bowen & Sosa, 1989; Boyer, 1990; Fairweather, 1996; Geisler, 1989). Affiliation with university research centers exacerbates quite significantly the strain that university scientists already endure. While there is, of course, a concern with individual stress and possibly burnout with both types of role strain ("intradepartmental" and "center-induced"), our chief interest here is in the policy implications of *center-induced role strain*. Is it useful to require that institutions with, typically, quite different norms and requirements compete for the time of workers? One argument for the multiple roles and cross-cutting requirements is that it is a useful way to bring traditional, conservative academic departments towards new ways of thinking about multidisciplinary work. Certainly, this was on the mind of Erich Bloch during the early discussions about the role of NSF centers. In Bloch's view (Bozeman & Boardman, 2004), academic departments are bulwarks against change. Strong measures are therefore required to overcome the inherent conservativeness of academic institutions.

However, critics of university research centers argue that these new institutions, especially those with strong ties to commercial concerns, often are inimical to traditional academic values, both research and education (Kleinman & Vallas, 2001; Slaughter et al., 2002). Aside from risks (or merits) of university faculty changing roles, there is also the possibility that competing demands will make them less productive in research and teaching. In sum, while the well-being of individuals is inherently important, the policy stakes of multiple roles and possible strains go beyond individual welfare.

Previous Studies

In the interest of space and to avoid duplication with previous work, we do not provide a comprehensive literature review here. However, we do provide detail on those studies directly related to this one. We note that the role strain of academic researchers calls upon four literatures: (a) studies of role strain in professional science (in industry as well as university laboratories); (b) more general, studies of “organized research units” or ORUs; (c) more general still, studies of scientific work environments; and (d) more specific, studies of scientific values.

Role Strain in Professional Science

While role concepts, including role strain and role conflict, have received some attention in higher education (e.g., Colbeck, 1998; Faia, 1981; Fulton & Trow, 1974) and science studies (e.g., Box & Cotgrove, 1966; Gieryn, 1983) literatures, most of the theory and research using role concepts has been developed for other purposes and applied in other contexts. However, most studies using role concepts share common theoretical taproots. As is the case with so many developments in sociology, Robert Merton was one of the originators, honing the use of role concepts in the 1950s (e.g., Merton, 1957a, 1957b). Especially relevant to our work is Goode’s (1960) early formulation of role strain, viewed as “economic or allocative” in form, and of role relations (relations between managers and subordinates as well as between co-workers in general), seen as made up of a sequence of “role bargains” wherein individuals seek to minimize role strain through a perpetual selection process among distinct, and sometimes conflicting, role behaviors. This conceptualization of role strain has been used twice previously to study the research activities and aspirations of professional scientists. Nearly 45 years ago, [Evan \(1962\)](#) conducted a study somewhat similar to ours, examining the role strain experienced by industrial scientists and determining that reports of role strain vary according to the character of the research and development (R&D) performed by the scientist.

Closely akin to work on role strain is research on role conflict. One of the first major works on role conflict was the path-breaking work done by Robert Kahn and colleagues (1964) on role conflict in organizations. This work proposed a “role episode model” in which the incumbent of a role interacts with “role senders,” those who influence the role incumbent and his or her conception and execution of the role. Kahn et al. hypothesized a dynamic social exchange process in which role execution is influenced by a variety of organizational and personality factors including organizational rank and status, hierarchy, communication styles, and

friendship patterns. The potential for conflict arises when role senders' expectations are not entirely congruent with the incumbent's role enactment or when the respective expectations for the incumbent's role performance conflict. The authors distinguish between objective role conflict, the actual status of expectations, and subjective conflict, which, while experienced directly by the role incumbent, might not align with others' true expectations. Details of more recent role conflict studies are available in literature reviews (Fisher & Gitelson, 1983; Van Sell, Brief, & Schuler, 1981). Box and Cotgrove (1966) use the related concept "role strain" to organize a typology of professional scientists and to argue that scientists go to work for the employer with which they have common scientific and professional values, thereby minimizing if not eliminating role strain that otherwise might result from incongruence between their own needs and desires as professional scientists and the interests and expectations of their respective employing organizations. For instance, the scientist interested in publications will not, at least as a first choice, work for an organization that devalues the publication of scientific findings but rather prefers that its scientists work on applied projects such as prototype development.

We review the details of these previous studies, especially of Box and Cotgrove's, as they relate to our analysis of MMURC scientists below. In doing this, we suggest some substantial amendments to the application of role theory to university scientists that are reflective of the relatively new situation of splitting one's work time and resources between academic departments and MMURCs. Suffice it here to report that our reconceptualization necessarily de-emphasizes earlier focus on the minimization of role strain (see Box & Cotgrove, 1966; Evan, 1962; Goode, 1960) as a key goal of university scientists and of professional scientists more generally. Our use of role strain is similar to that of Gieryn (1983), who examines competing professional ideologies navigated by scientists and the role strain that results. As is the case in Gieryn's work, we do not imply that role strain requires behaviors leading to its diminution. In part, this is because MMURC university scientists in most instances voluntarily increase their role strain (we discuss this further below).⁴

Also relevant is the substantial body of study on the multiple expectations that university departments have of their scientists, MMURC affiliation aside, though most of this research does not employ the sociological lens of role strain that we use here. Moreover, these studies lack the interorganizational component of the current analysis; rather, they focus on strain produced by one role sender, the academic department. The majority of this work describes how university faculty members allocate time and energy to various departmental activities, the key area of inter-

est being time allocated to teaching versus time allocated to research and publishing (Bowen & Sosa, 1989; Fairweather, 1996). Many of these studies promote alteration of the academic reward system to give equal (or at least more) weight to nonresearch activities such as teaching (Boyer, 1990; Braxton & Del Favero, 2002; Diamond, 1993, 1999; Geisler, 1989). Most recent is a study that shows that despite these calls for reform, not much has changed. [Fairweather \(2005\)](#) demonstrates hours spent in the classroom per week to be significantly and negatively related to pay in U.S. universities, from 1992–1999.

Organized Research Units

The MMURCs with which we are concerned here are perhaps the most organizationally and scientifically complex version of what the higher education literature refers to as “organized research units” (ORUs). Systematic study of ORUs date to the early 1980s (Friedman & Friedman, 1982), including Geiger’s (1990) historical account of the decisive role played by university research centers in post–World War II university science, focusing on the mediating role that centers have played (and still play) between public knowledge demands and the scientific capabilities and research of university scientists. Geiger also notes that ORUs have been around since the late nineteenth century—for instance, the Harvard Observatory was established in 1844—though we maintain here, as we have suggested in previous study (Bozeman & Boardman, 2003), that those centers that are problem-driven, multipurpose, multisector, and multidiscipline (such as ERCs and STCs) are products of the competitiveness crisis that occurred in the U.S. during the late 1970s and early 1980s.

One study (Dooris & Fairweather, 1992) in particular addresses the scientific values of university scientists working in ORUs as well as in academic departments. Though the authors do not discuss explicitly center-induced role strain and the way that university scientists manage it, their findings imply that this type of role strain is indeed a growing problem for university scientists, one that is not going to go away anytime soon. Dooris and Fairweather (1992) find that faculty members value more the norms of their respective disciplines than those of the centers for which they work, concluding that if ORUs are to affect the values and more importantly the behaviors of university scientists, the structure and culture of these centers must match the values and norms of faculty (i.e., departmental) culture.

We avoid using the label ORU in this paper because the term is perhaps too broadly defined for our purposes. Stahler and Tash (1994) recognize this, acknowledging that the only characteristic common to

ORUs is that they have research as their primary mission. This is not the case, however, once one focuses on particular types of centers. Bozeman and Boardman (2003) present a taxonomy of university research centers along specific measures for interorganizational relations and internal activities. Most MMURCs have in common (a) horizontal relations: which are complex, cutting across many different units of the university, including multiple departments and sometimes other centers; (b) external relations: also complex, including multiple ties to industry, government, and other universities; (c) extra-research activities: multiple, including educational roles, industry interaction, scientific and professional brokering, and also community outreach; and (d) research focus: entirely problem driven, not tracking closely to disciplines and established scientific and technical specializations (Bozeman & Boardman, 2003).

Scientists' Work Environments

Early studies of scientific careers and professional norms provide clear distinctions among university researchers, industry researchers, and researchers in government laboratories (Andrews, 1979; Pelz & Andrews, 1966). Generally speaking, the role of industry researchers was portrayed as the production of proprietary knowledge that could be applied for corporate profit (Kornhauser, 1962; Marcson, 1960). Whether working in weapons laboratories, agricultural laboratories, or any of the other variegated agency research performers, government scientists and engineers were assumed to have their jobs defined by the statutory mission of their employing agency or department (Marcson, 1966). While never quite so imprisoned by the ivory tower as legend would have it, university scientists were generally characterized as autonomous, curiosity-driven devotees of knowledge for its own sake, with little regard and opportunity for commercial gain (Smith & Karlesky, 1977).

The stereotype of scientists' work environment never captured all the variety one finds in the U.S. national innovation system. While science institutions were in many respects more stable in the 1960s and 1970s than they are today, the within-group differences among sectors have long been nearly as pronounced as the between-group differences, and, indeed, research institutions have been in the forefront of trends toward sector blurring and hybridization (Bozeman & Crow, 1990; Crow & Bozeman, 1987, 1998). But if the U.S. scientist's work environment has never been a placid one, it is nonetheless true that the past few years have witnessed developments providing step changes in the level of institutional complexity experienced by scientists, especially academic scientists. Our analysis, current and previous, reveals the MMURC as

central to this discourse on institutional complexity and academic science, with role strain constituting a side effect requiring clarification and remedy.

Scientific Values

Classic studies on the scientific identity and the ethos of science suggest that the decision of the scientist to work in industry or in academia is a value-laden one (Barber, 1953; Merton, 1957a). Other milestone works (Blissett, 1972; Blume, 1974; Hagstrom, 1965; Kornhauser, 1962) more generally emphasize the conflict between the needs of professionals, who demand autonomy in practicing their expertise and the needs of the organizations that employ them, which expect employee compliance among other behaviors. Both of these themes—individual values and the divergence between employee and employer expectations—are central to describing who the MMURC scientists are (what scientific goals they identify with) and to explaining why they choose to work in both the MMURC and the academic department, given the role strain that this scenario can produce. Keeping in line with this literature, we propose that the decision of the university scientist to affiliate with an MMURC is a value-laden one.

Data and Method

In analyzing the role strain that some university scientists experience as a result of dual allegiance to an MMURC and an academic department, we employ data based on intensive semistructured interviews. In this section, we describe in detail who we interviewed, how we selected the interviewees, and the protocol we used during the interviews. We qualify that, as with all studies using semistructured interviews, the data we developed are subject to multiple interpretations. Thus, the original data are available from the authors (with identifying information removed in order to preserve confidentiality).

The Sample

We interviewed 21 university scientists who, at the time of their interview, worked in an ERC or an STC and also occupied either a tenured or a tenure-track position in an academic department. Further, when we interviewed these university scientists, each was working in U.S. “research extensive” universities (as defined by the Carnegie Foundation for the Advancement of Teaching, 2004).

We did not select the interviewees randomly. In a questionnaire-based companion study, we had developed a sampling frame of 1,600 faculty

researchers.⁵ From the 39% of this sample who indicated affiliation with a university research center, we identified as best as the available (i.e., online) information allowed those scientists working in ERCs or STCs. We focused specifically on ERC and STC faculty members because each of these MMURCs, being among the more complex and multifaceted university research centers, seem to have especial potential for the type of role strain in which we are interested here, if for no other reason than the fact that these centers require their faculty to occupy tenured or tenure-track positions in academic departments (Bozeman & Boardman, 2003, 2004).

After more than a year spent developing the sample for the companion study and developing secondary data from public documents and Web sites, we began the selection of interviewees for this study. It would have been possible to have developed an entirely separate roster of potential interviewees, one that had nothing to do with the sampling frame we had previously developed. We decided not to do this because, in the first place, the previous sampling frame had been vetted. Nearly 30% of faculty listed on Web sites were either miscategorized, no longer affiliated with the center, no longer affiliated with the university, retired, or deceased. Since the previous sample was carefully vetted, drawing from this source decreased problems of identifying valid “cases” (interviewees). In addition, we had developed secondary information—chiefly characteristics of the centers—that we thought might be useful in connection with our interviews (but which, ultimately, we chose not to incorporate in the study).

From among the sample, our selections were based on a desire to obtain variation with respect to the centers’ size and affiliation, substantive focus, and organization designs. We were also interested in interviewing center affiliates at different career levels. Having previously gathered a great deal of quantitative information about these centers, we were able to select interviewees that met our criteria. Each of the 21 we queried agreed to the interview (i.e., no refusals). While we did not have a respondent selection key or similar formal selection instrument, we systematically sought to meet the criteria that seemed most important to us (diverse type and size of center, diverse organizational structures and designs, tenured and tenure-track, male and female).

In semistructured interviewing there is, of course, no rule for selecting the number of interviewees. We chose to interview 20 individuals for our purposes (and one was added so as to include one additional junior faculty member). While these 21 interviewees would likely be inadequate if our focus was more generally on university research centers (there are thousands of affiliates with university research centers of all

types), the number seems more tractable when one considers that our focus is only on active NSF ERCs and STCs. Among the interviewees, about half were tenured (with the remaining being untenured but tenure-track), 60% were male, and about half were engineers, with the rest being natural or life scientists.

The Interviews

Each of the 21 interviews we classify as “extended” required 1 to 1.5 hours. They were conducted by telephone from August 2003 to August 2004, though one (with a scientist at our home institution) was conducted face to face. Our the interview protocol (see Appendix) was designed to decipher the nature of scientists’ relationships with their respective departments and with their respective ERCs or STCs. We included questions regarding the incentives for scientists to affiliate with their research center in addition to the department, the activities and tasks their departments and centers expect them to perform, the perceived benefits and costs of center affiliation, and, most importantly, any perceived or real conflicts resulting from their dual allegiance to a department and a center.

During the interviews, we employed probes informed by role theory and the concept of role strain, per previous works that we discuss below (Box & Cotgrove, 1966; Goode, 1960). To illustrate, our questions about scientists’ incentives to affiliate with a university research center included among numerous other incentives Merton’s (1957) three clusters of scientific values: “autonomy,” “disciplinary communism,” and “personal commitment.” Respectively, the interview items designed to reflect these incentives include “I work in a center because it allows me to choose the direction of my own research” (autonomy), “I work in a center because it allows me to publish my research results” (disciplinary communism), and “I work in a center because of my personal commitment to being a scientist” (commitment). More importantly, in our interview protocol and probes we adhered to extant theory regarding different types of role strain, including Goode’s (1960) substantive distinction between “inter-role” role strain (i.e., when one has multiple jobs to do for multiple overseers) and “inter-sender” role strain (i.e., when one has multiple overseers who expect contradictory behaviors) as well as organizational level distinctions (e.g., *within*-department or *within*-center role strain versus *center-department* role strain).

It should be noted that closed-ended questions such as those above (Merton, 1957) constituted but a small component of the interviews. For a majority of the interview time, we allowed scientists to speak freely of their experiences in departments and centers, interjecting when appro-

appropriate with probes regarding the topic of center-induced role strain as well as related topics including, for example, the academic reward system's focus on peer-reviewed publications. Before discussing the results of our interviews, we consider in the next section the conceptualization of role strain and the applicability of attendant role theory to academic scientists working in the unusually complex institutional environment we have referred to as the MMURC.

Conceptualization of MMURC Role Strain

In this section, we discuss the conceptualization of role theory, especially as it pertains to role strain. One objective is to compare the role strain reported by academic scientists today, in what we have termed previously the “era of interinstitutional research collaboration,” to the role strain assessed in studies of academic scientists whose careers precede today's “center-oriented” context for funding university-based science with public monies. The goal of prediction we must reserve for subsequent study using data that is decidedly different from that we employ in this study, data with an institutional, rather than an individual-level, focus.⁶

Conceptualization of Role Strain

What the organizational stress literature refers to as “role strain” is not as precise as some concepts. For example, “role strain” and “role conflict” are in many cases used as substitutes. We prefer the role strain label inasmuch that conflict often implies active disagreements among parties whereas role strain generally pertains to perceptions of individuals occupying the role. Generally, role strain refers to the circumstance in which individuals are subject to competing demands in the workplace, in the home, or elsewhere. [Goode \(1960\)](#) and others who are concerned more specifically with the work experiences and work environments of professional scientists ([Box & Cotgrove, 1966](#)) employ the concept of role strain as an essentially economic or rational function wherein individuals minimize to the greatest extent possible the amount of role strain that they endure in their respective work environments. Scientists do this by choosing to work for the type of research organization—or more precisely, the sector of research organization (i.e., university versus industry versus federal)—that holds expectations that best match their own professional aspirations (e.g., scientists who want to publish work in academia, scientists who want to develop patents and prototypes work for industry), thereby increasing to the greatest extent possible the utility they may derive from their respective careers as professional scientists.

This logic of role strain must be altered somewhat to assess the modern university scientist who splits time between an academic department and a university research center. For this type of scientist, role strain minimization is not a key factor in job choice (inasmuch as center affiliation is voluntary) but rather one of many aspects to consider when deciding to affiliate with an MMURC. Despite the disparate authority lines and reporting relationships that the MMURC poses—as well as the concomitant increase in research, teaching, and administrative workload—many university scientists nevertheless opt to add MMURC work to their departmental workload, potentially increasing their respective levels of role strain. We discuss this decision and its effects further in the sections below.

The vocabulary of role theory is straightforward and useful for describing the situation of the university scientist with dual allegiances. Such a scientist has two key “role senders,” two organizations to which she is beholden to fulfill research and other duties: the MMURC and the academic department. Before assessing the expectations of each role sender and how they sometimes create role strain for these university scientists, it is important to note that as individual institutions the academic department and the MMURC, by themselves, expect multiple role behaviors of the university scientist that sometimes compete or conflict, thereby creating intrainstitutional role strain. This is the type assessed in the early organizational stress literature. Academic departments, for instance, expect their faculty members to fulfill numerous roles, including those of researcher, teacher, and administrator to the department, which oftentimes have crosscutting and conflicting objectives regardless of the scientist’s external role obligations to an MMURC (Bozeman & Boardman, 2003). Similarly, the MMURC expects from their bench scientists research, administrative, and student-mentoring behaviors, not accounting for the role expectations of the academic department. Though it is an important topic in its own right, in this paper we do not consider intrainstitutional role strain in our assessment of the university scientist with dual allegiances, as it has existed as long as have universities and is adequately addressed by the classic role assessments of scientists discussed above.

According to role theory ([Biddle & Thomas, 1966](#); [Goode, 1960](#)), university scientists with dual allegiances may experience “inter-role” role conflict when their “role senders,” the MMURC and the academic department, expect of them behaviors that are incompatible or at least in competition with one another. The most conspicuous instance of inter-role role conflict is caused by a general divergence in research interests between the MMURC and the traditional academic department. The

research efforts of the MMURC are almost always organized by problems (e.g., earthquakes, semiconductor packaging, tissue engineering) rather than by discipline (e.g., geology, physics, chemistry) and are aimed at research application and commercial development. The traditional academic department, in contrast, concerns itself with the extension of basic knowledge and publication in peer-reviewed scholarly journals.

University scientists with dual allegiances also are subject to “inter-sender” role conflict, which is, theoretically, a by-product of inter-role role conflict. University scientists experience inter-sender role conflict when role expectations from equally legitimate role senders directly conflict, creating the problem of work overload (MacKinnon, 1978). For the university scientist with responsibilities in the academic department, affiliation with an MMURC does not reduce the commitment to committee meetings, it expands it; it does not limit the time mentoring students, it increases it; it does not simplify the research and technology portfolio, it makes it more complex.

Taken together, inter-sender and inter-role role conflicts further tighten the tension wires among the diverse activities that academic units string together. Generally, academic departments see research collaborations and cross-departmental or cross-institutional activity as leading to a decrement of department resources through either lost research dollars or the lost time of researchers. Not only do department faculty who have grants and contracts with an MMURC have less time for research and publishing within their own discipline, but they also are less likely to be available to teach the department courses for which students have paid tuition and to have sufficient time for such organizational maintenance activities as hiring and promotion committees.

Operationalizing Role Strain

Following the logic and vocabulary of role strain, we developed an interview protocol composed of both structured and semistructured items (see Appendix). Our operationalization of role strain includes both inter-role and inter-sender role strain.

“At-risk” University Scientists

To identify scientists at greater risk of role strain, owing specifically to their dual allegiances to departments and centers, we asked respondents to indicate on a Likert-type scale (1 = Strongly Agree, 2 = Agree Somewhat, 3 = Disagree, 4 = Strongly Disagree) the extent to which they can distinguish their departmental duties, research and otherwise, from their center duties, research and otherwise. These tasks and duties

include research (“My center research and department research are sufficiently separate that I can easily distinguish between them”), journal publications (“The articles I publish from my center research are separate and distinct from those I publish from my department research”), grants and grant support (“With respect to the grants that support my research, I can easily distinguish the department grants from the center grants”), and student mentoring (“I can distinguish between the department students that I mentor and advise and the center students that I mentor and advise”). Our reasoning was that respondents indicating a high level of agreement with these statements would be more likely to report having experienced role strain (the operationalization for which we discuss immediately below) than would respondents disagreeing with these statements, in that clearly distinguishable tasks and responsibilities suggest clearly distinguishable, and therefore potentially competing, role senders, role expectations, and role behaviors. Moreover, to further distinguish university scientists with dual allegiances who are more “at risk” of role strain, we asked our respondents, using the same Likert-type scale, about center and departmental expectations regarding industry interaction (“Interacting with industry is a center, not a departmental, expectation”) and regarding collaboration with other universities (“Collaborating with people at other universities is a center expectation, not a departmental one”). Again, higher levels of agreement indicate a higher risk of role strain.

Indirect Proxies of Role Strain

After determining which university scientists are more likely to report high levels of role strain, we asked respondents indirectly about any conflicts amongst the many tasks and behaviors expected of them by their respective departments and ERCs or STCs. We asked respondents whether their departments reacted “positively,” “negatively,” or “with ambivalence” toward one or more of the following activities and tasks that they indicated earlier in the interview having performed for either an ERC or STC: writing articles for publication, mentoring students who are not members of the department, administrative and committee work, grants work, and industry work that has no link to the department. We interpret negative responses as indirect evidence of role strain resulting from dual allegiances to departments and centers.⁷ Another indirect indicator of role strain that we employ in our interview protocol is an item about departmental rewards and punishments. We ask respondents, “What center work, if any, does your department acknowledge, reward, or punish?” This approach is comparable to the approach we discuss immediately above, but it is open-ended to cover activities beyond

research, publication, administrative and committee work, student mentoring, and grants work. We interpret “punishment” responses as indirect evidence of role strain resulting from dual allegiances to departments and centers. Again, we consider this evidence indirect because of the assumption that perceptions are reflective of reality and because of potential response bias or other problematic phenomena specific to survey and interview data-gathering methodologies.

For both of these indirect probes, we also implemented the questions in reverse, asking about center attitudes, approaches, and policies toward departmental role expectations, such as, in addition to publishing articles in peer-reviewed scientific journals, teaching and committee work. Similarly, we interpret negative and “punishment” responses to these questions as indirect evidence of role strain. The above-mentioned qualifications (about the assumptions we make in this interpretation) apply.

Direct Indicators of Role Strain

After indirectly assessing the presence or lack of role strain in university scientists with dual allegiances to departments and centers, we ask more direct questions about role strain that are reminiscent of the classic studies on the topic. To start, we ask respondents “Do you ever feel that your center’s and department’s respective expectations of you conflict or are incompatible? If so, in what respect is there conflict or incompatibility of expectations?” In instances of affirmative responses, we probe as to the specific nature of the role strain, in particular whether it constitutes inter-sender role conflict (work overload), inter-role role conflict (work incompatibility), or some combination thereof. Unlike the indirect proxies for role strain mentioned above, these indicators are open-ended interview responses.

Interview Results

Though our chief goal in this study is to describe the experiences of university scientists working simultaneously in departments and centers, because of our earlier study (Bozeman & Boardman, 2003) we could not help but harbor some expectations going into the interviews. Accordingly, in our presentation of the results we employ a macro-approach (considering any consistencies or lack thereof across the interviewees’ responses) and a micro-approach wherein we discuss in detail the responses of individual interviewees. We qualify that from these results we do not intend to generalize but rather to construct multiple stories around the diverse experiences of university scientists working in centers and departments.

At the outset of this study we expected university scientists who could more easily distinguish between their departmental and ERC or STC duties (those we consider above as “at risk”) to be more likely to report role strain. We also expected that university scientists working in departments that react negatively to or employ negative incentives regarding MMURC-related tasks and activities to be more likely to report instances of inter-sender and inter-role role conflict. This is what our interview data generally reveal.

Which MMURC Scientists Experience Role Strain?

In this subsection we briefly but necessarily take a macrolevel approach to our interview data to identify any trends in reported role strain. One would expect to see certain trends (e.g., engineers versus natural and life scientists, tenured versus untenured) in reports of role strain amongst university scientists affiliating simultaneously with centers and departments. However, our interview data showed no individual-level consistency in reports of role strain. Some junior-level (tenure-track but not yet tenured) biologists experience role strain, while others do not. Similarly, some tenured engineers report conflicting demands on their work time, while other engineers with tenure cannot distinguish between their center and departmental tasks and outputs.

In fact, in all of our interviews, we found no consistency in reports of role strain across a broad array of personal and professional characteristics, including gender, discipline, tenure status, and length of tenure in the center and department, as well as whether the scientists must perform for an MMURC, in addition to research, the following tasks: administrative and committee duties, work on grants or grant proposals, student mentoring, and industry interaction including activities ranging from informal sharing of research results to consulting to work on discrete outputs like prototypes and patents. Similarly, we found no coincidence of role strain reports and the level to which respondents felt encouraged by their departments to affiliate with an MMURC (which we discuss in detail below).

However, at the institutional level of analysis, role strain becomes more “predictable.” For those scientists reporting role strain, we noticed that the network ties connecting their respective MMURCs and academic departments to be more “formalized” (as perceived by the interviewees) than not. From our modest number of interviews, we noticed quite a lot of variation in these ties. At one extreme, the center constitutes but a subunit of the academic department, with the department head having managerial authority over center research and related activities. Reports of role strain in this and like instances are practically nonexistent. At the

other extreme, the center seems to have no ties whatsoever with the home departments of its faculty affiliates. Perceived role strain in this scenario becomes commonplace, though not ensured, according to our interviews.

For the remainder of our results, we use both the macrolevel and microlevel approaches to our interviews, interjecting when appropriate scientists' anecdotes and experiences in their centers and departments.

Results for "At-risk" University Scientists

A key element of potential role strain is simply being able to distinguish among roles and the requirements of different roles. Thus, we sought to determine the extent to which scientists could distinguish their role demands for the department from those for the center. We consider the ones who could distinguish their roles "at risk" for role strain. For instance, a full professor and biochemist working in an ERC reported, "There are certain things that I do that are only for my center-funded research. I can distinguish my grants. . . . I know that a recent experiment is basically for the center. I can always distinguish." In contrast, an assistant professor and mechanical engineer, working in another ERC, reported the following regarding the distinction between her "department" grants and "center" grants: "The decision [to attribute a particular grant to the center or to the department] is somewhat arbitrary. I have to make the distinction when writing the grant proposal, but I feel that this type of distinction is arbitrary."

The majority of our interviewees could distinguish on at least one count their departmental responsibilities from their MMURC responsibilities. The responsibilities we asked about included research, articles, grants, and students (see the Appendix for the full protocol). We noticed a consistent relationship between being able to distinguish center research from departmental research and being able to distinguish center articles from departmental articles. For instance, an associate professor and mechanical engineer who reported that his center and departmental publications are "not at all related" said the same regarding the research he conducts. Conversely, a full professor and neuroscientist reported that his center and departmental research and publications are "one in the same." This sort of positive alignment was not the case for other combinations of responsibilities.

Few respondents reported that they could distinguish their center duties from their department ones on all four counts (research, articles, grants, students). The respondents who could make a distinction for two or more activities (e.g., research and articles, grants and students and articles), we consider to be "at risk" of role strain. Though our goal in this

article is first and foremost descriptive, we nevertheless expected that these scientists would be more likely to report negative feedback from their departments regarding center activities and more likely to report instances of inter-sender and inter-role role conflict. Conversely, the university scientists who could distinguish only one or zero of their responsibilities from department to center we consider “low or no risk” and expected to respond negatively to our indirect and direct role strain probes. As we demonstrate in the next two subsections, we were correct in only some of our expectations regarding indirect indicators, though we were quite on track regarding the direct indicators.

Indirect Proxies of Role Strain

Despite our expectations, university scientists who are “at risk” of role strain because of dual allegiances to departments and centers did not respond as we expected to our indirect indicators of role strain. Generally, the respondents indicated that their respective departments viewed publications based on ERC or STC research either “positively” or “with ambivalence” (rather than “negatively,” as we initially expected). Typical comments by interviewees indicating that their departments respond “with ambivalence” to center-based publications included “The department doesn’t respond. They don’t recognize [center-based publications] as being different than [departmental publications]” and “The department doesn’t have any formal measurements or non-measurements for center publications. . . . It really is fairly agnostic.” Among the more positive responses, one interviewee acknowledged, “Every time I have to spend time working on [center publications], I have had full support from my department and chair. Overall I have been very pleased with the support that I get.” This we explain with departments’ heavy weighting of publications in peer-reviewed journals during tenure and promotion decisions. Similarly, our scientists typically gave positive responses regarding their departments’ responses to working on center grants, another output coveted by departments.

Our interviewees also made some negative comments—comments indicating departmental dissatisfaction with time allotted to MMURC-related work—regarding (a) mentoring center students who do not belong to the department, (b) working with industry in a nondepartmental capacity, and (c) performing administrative and committee duties for the center. Not all of the university scientists we considered to be “at risk” of role strain, however, indicated that their departments view at least one of these activities in a negative light. A tenured computer scientist offered a typical response, “From the perspective of the department, it is also viewed as negative in a sense because it takes faculty away from the

department. . . . I don't think the department considers who I advise as relevant." This and like responses we explain as sensible in that none are behaviors that directly benefit the academic department. Moreover, these activities essentially constitute time and resources taken away from the department by the center.

Our open-ended indirect indicator of role strain—the protocol item about departmental rewards and punishments—yielded no useful results. Instead of answering the questions, many respondents took issue with the idea of departments “punishing” center-related work and activities, though they had no problem with the reverse concept of departments “rewarding” behaviors. The data is therefore too inconclusive for systematic interpretation and, accordingly, we omit it from our discussion and analysis below.

Direct Indicators of Role Strain

Many of the university scientists we interviewed whom we consider “at risk” of role strain reported having experienced either work overload (inter-sender role conflict) or incompatible role expectations (inter-role role conflict) caused by their dual allegiances to centers and departments. These scientists, moreover, were the same ones who observed (above) departmental tension regarding their center duties and activities. Also as we anticipated, none of the “low to no risk” scientists indicated experiencing much, if any, role strain.

Our interviews included reports both of inter-sender role conflict (which for university scientists amounts to work overload because of dual allegiances to centers and departments) and of inter-role role conflict (which for university scientists is not additive but rather an issue of compatibility), though inter-sender role conflict was more common. Seldom did the same university scientist comment on experiencing both types of role strain.

One untenured but tenure-track engineer working with an ERC in addition to her academic department was quite calculating when discussing work overload resulting from inter-sender role conflict between her center and department: “If the center wants to claim 25% of my effort, and then I have effort on my grants, so there's maybe 10% left to apply to the usual teaching. . . . So this is going to have to change.” While acknowledging that work overload is a negative aspect of dual allegiances to a department and center, another scientist, a tenured biologist, was more reserved in his report of inter-sender role conflict: “I view [my center work] as a kind of time-filler; when I'm waiting for my data to come in on my [departmental] research. I can stop and write a [center-related] article very easily.” The same scientist continues, “I

would say the department just looks at [my center work] as, ‘Okay, if you want to take on this extra work that is up to you, but we won’t give you any credit for it.’” A microbiologist working in an STC offered this perspective:

My department makes it very clear that I can participate in [center] activities, but I am still expected to fulfill my duties in the department. When I plunge into the center work I know that from the beginning. It creates a lot of extra work.

Reports of inter-role role conflict constitute perhaps the more interesting and policy-relevant component of our interview data. An untenured but tenure-track scientist working in a biology department as well as in an STC reported:

I think the role of an assistant professor in a center is kind of a difficult thing. Sometimes I feel ungrateful because the center has given me so much but at the same time I resist some of the things that they ask me to do because I know that it’s not going to help me in my own career as I get started.

A tenured computer engineer who was “strongly persuaded” by his department chair to begin work with an ERC reported:

Just simply the expectations of the [my department] are somewhat different from the center side. So, spending time with industry and putting together large collaborations are much more of a center based expectation and not so much a [departmental] expectation. Doing so definitely takes away from classical faculty activities and this can be binding. The work is separate and not very compatible with what my department wants me to spend my time doing.

These reports of inter-role role conflict are indicative of the fundamental differences between traditional academic departments and MMURCs on numerous levels: their missions as research and educational organizations, their reward systems, their expectations of the scientific faculty under their employ. We discuss these differences and the implications of role strain for funding university-based and center-oriented science in the discussion section below.

Discussion

Our data suggest that today’s university scientists are subject to a quite different set of institutional arrangements and authority lines than were the professional (university or otherwise) scientists upon which the early role strain studies focused. That we even have a sample suggests the logic employed in these studies no longer applies, at least not universally. The scientists with dual allegiances to a department and an

MMURC, unlike their predecessors working before the advent of university research centers, in a sense volunteer for rather than minimize role strain.⁸ For university scientists with dual allegiances, role strain minimization is not a key driver of job choice but rather one of many aspects to consider when deciding to affiliate with an MMURC, usually after they have established themselves in a tenure-track or tenured position in an academic department.

The picture of role strain that we present above is indicative of more than the historic ideological distinction between basic and applied research (inter-role role conflict) or of work overload (inter-sender role conflict). In addition, it is a product of the capacity limitations of each role sender, the MMURC and the academic department, to which the MMURC scientist is obligated to fulfill role expectations. Accordingly, role strain for the MMURC scientist generally remains unmitigated, suggesting, as have others (Etzkowitz, 1998), a curb on the impact of the “second revolution” in university research on traditional academic values in the American university system.

First, academic departments generally are ill equipped to evaluate center research when making salary and promotion decisions, as the departments differ little today from those of the 1920s and are similar in disciplinary orientation, educational functions, and rewards systems (Bozeman & Boardman, 2003). Brooks (1978) and others (Arocena & Sutz, 2001; Porter & Rossini, 1985) have found that the academic department cannot adequately peer review interdisciplinary and applied research proposals.

Second, relative the academic department, the MMURC has few resources with which to entice university scientists to conduct interdisciplinary and applied research. Though potential science and technical human capital gains (Bozeman, Dietz, & Gaughan, 2001) as well as humanitarian goals and additional resources can lure university scientists to affiliate with an MMURC, our interview data suggest that once these scientists join the center they engage in the role strain minimizing behavior that the early organization stress literature discusses. According to center directors, the MMURC has mostly indirect means to entice its bench scientists to perform desired role behaviors. Directors’ comments about this limited leverage include the following:

One of the realities is the intrinsic problem of bringing professors into a joint project and getting them to buy into it. Professors are hired for their independence. The management skill is in creating a vision that many can buy into and share. . . . I have to do sales work. I have to focus on the general value-added that people have gotten from the ERC and make sure they recognize the impact of our, say, \$60,000 and get them to appreciate it.

There is no question that this issue is the biggest struggle and requires the most time and commitment. When we are trying to add something else to their agenda, they have to be convinced to give up something else. They have to decide that they want to move forward in that direction. People are driven by their own self-interests and if they recognize that what we want them to do is something they want to do, they will do it.

Another MMURC director offered an especially cogent summation of this problem, quipping that he manages his faculty with “a big carrot and a little stick.”

Implications

In this section, we consider the implications of our findings about role strain from three different perspectives—the university, the department, and the individual. At each level, the general implication is that *center-induced role strain creates more work, contradictory expectations, and prevents university scientists from performing as their centers and/or departments would like them to*. Accordingly, at each level we discuss the nature of academic incentives and rewards. It is nearly impossible, for example, to discuss the tenure-track scientist working in a biology department as well as in an STC who admits to shirking some of her center responsibilities without also considering her comment that she is most focused as a scientist on those tasks that can “help [her] in [her] own career as [she] get[s] started.” Our intent simply is to identify potential problem areas for policymakers and government managers overseeing center programs, assuming that the status quo with regard to MMURC-induced role strain is to persist. We save our discussion of how policymakers may approach these problem areas for the conclusion.

Dilemma 1: At the University Level

Some have expressed concern that research quality may be on the decline in the U.S. (Hampel, 1995). Universities have in place few mechanisms with which to ensure against university scientists overextending themselves by becoming involved in multiple research missions, and often those mechanisms that are in place are not heeded by the MMURC, the academic department, or both. As we present above, even when centers and departments engage in “cost-sharing” agreements to reduce teaching loads, the scientist does not always necessarily benefit; role strain is not always reduced. Further, university administrators often incorrectly assume that extra-departmental research units such as MMURCs have no problems in getting untenured university scientists to engage in applied research and related technology-transfer activities

(Friedman & Friedman, 1985). The administrative structure of many universities was developed to manage curricula, not interdisciplinary and university-industry collaboration, and those research administration structures that have been added in response to commercial and interdisciplinary enterprises have been added haphazardly (Bozeman & Boardman, 2003).

Dilemma 2: At the Department Level

Similarly, there exists a lack of congruence in the U.S. university system between the problem-driven activities that the “Carnegie Extensive” university encourages and the capacity that academic departments have for evaluating faculty performance. Brooks (1978) argues that departmental peer review is suitable for defined fields but not for interdisciplinary fields and that it can be used for assessing new knowledge for its own sake but not for measuring the usefulness or applicability of that knowledge. More recently, Bozeman and Melkers (1993) suggest that peer review is ill suited for assessing commercially relevant work, while Siegel, Waldman, Atwater, and Link (2003) suggest that there may be bias in tenure and promotion decisions favoring single-discipline and basic research over applied and commercially relevant projects. This may prove to be increasingly problematic for academic departments as more graduate students are trained in an MMURC context and, accordingly, pursue similar work as faculty later on. It has already been shown to be problematic for scientists’ valuation of applied and commercially relevant research, with untenured but tenure-track scientists working in MMURCs preferring basic research when compared to their tenured colleagues (Boardman & Ponomariov, in press).

Dilemma 3: At the Faculty Member Level

For faculty, especially assistant faculty who have yet to receive tenure, participation in MMURC research may be perceived as time and effort taken away from potentially (academic) career-advancing activities. This is clear from our interview data as well as from directly related research (Boardman & Ponomariov, in press), and it is a direct consequence of the university- and department-level dilemmas identified above.

Barring a massive cultural upheaval in the U.S. university system or a change in the NSF requirement that MMURC scientists be tenured or tenure-track members of an academic department, role strain will remain a fixture of university culture. Affiliating with an MMURC in addition to an academic department creates for the university scientist inter-role and inter-sender role conflicts, two prevalent types of role

strain. One director of an STC we interviewed was especially pessimistic: "Either universities need to evolve or [role strain] will become a serious problem. But universities have not evolved this way." For the time being, it seems that the scientist's choice is either to opt out, thereby foregoing the considerable resources of the MMURC, or to join the center and seek to balance the demands of an ever more complex work environment.

Conclusion

The issue of role strain among participants in university centers is obviously of interest at the level of the individual. The policy implications of role strain are perhaps less obvious, but they are just as worthy of attention.

While centers and center programs are not, of course, set up with the explicit intention of encouraging role strain, they do sometimes require dual and multiple allegiances. Let us consider the example of the NSF Engineering Research Centers Program, one of the oldest and best-known government programs for university research centers. As we mentioned above, in a previous article (Bozeman & Boardman, 2004) we interviewed Erich Bloch, the science policy official who is, perhaps, most associated with the establishment of MMURCs. As part of the background work for that study and related research, we also interviewed Roland Schmitt, Chair of the National Science Board during the Reagan administration, and Lynn Preston of the National Science Foundation, a program officer in the NSF Engineering Directorate who has had major responsibility for the ERC program. All agreed that the decision to *require* that faculty associates of ERCs (and, later, NSF Science and Technology Centers) be tenured or tenure-track members of an academic department was not made lightly. There was a concern that university research centers should not be a home for academic refugees who did apply for or who were denied tenure. It was assumed that the scientific importance and research effectiveness of the centers would be enhanced if all affiliated faculty members had tenured or tenure-track appointments. There was never any doubt that this would potentially place some extra burdens on the participants. When told that some of our earlier interviewees (Bozeman & Boardman, 2002) were concerned about essentially having two jobs rather than one and about the possible resulting "burnout," Bloch responded:

The ground rule is a faculty member at the center has to be a member of a department. . . . They can't just belong to a center. The problem isn't the centers; it's the departments. I'm against academic departments. I think they should get rid of them. There is no such thing as chemical engineering or

mechanical engineering by themselves. They meld. This dual responsibility you talk about is unavoidable. If someone can't take it, then they should get out. It seems to me that it's up to the individual. (Bozeman & Boardman, 2004, p. 372)

It is, of course, "up to the individual," and it does seem that most individuals are choosing to sustain the additional work for the additional resources and other incentives (including prestige and access to students and, sometimes, to industry). Despite the fact that these academic faculty seem to be freely making the choice of more work and increased role conflict, that choice does not, of course, imply that the policy is (or is not) wise. Arguably, researchers who are more focused might very well be more productive, even working fewer hours and having fewer resources. Arguably, researchers who have the pressures of dual or multiple allegiances might have a higher "dropout" (from academic careers) rate than those who do not. Arguably, the advantages of having more and more graduate students and postdoctoral students to work with might be offset by the time for high-quality interaction and collaboration. Role strain almost certainly necessitates a fragmentation of work activity, with the possibility of decrements in both efficiency and morale.

Our study is limited in that we use only interview approaches. We feel that the question of role strain remains significant for future research, but it will be useful to employ multiple methods and to examine the implications of role strain for concrete behavior. Are the work patterns of center affiliates different than those of scientists who are not affiliated with centers? In all likelihood, most faculty members experience some level of role strain. But do center affiliates experience more or different strains? Companion studies (Gaughan & Bozeman, 2005; Lin & Bozeman, 2006) suggest that center affiliates report spending less time on teaching and departmental administration but more time on research administration and external service. However, these findings are rudimentary and insufficiently nuanced. It seems likely that the *type* of center makes a great deal of difference in academic researchers' work experiences. Until we have valid, reliable, and, preferably, multimethod studies of the composition of work in academic departments and in diverse sets of university research centers, it will be impossible to know the extent to which university researchers' (and governments') investments in research centers are yielding sufficient returns.

Though "small science" is rightly the primary mission of the academic department, today's scientific challenges seldom come shrink-wrapped in a single discipline's packaging. A next step in understanding MMURC role strain should entail direct comparison of affiliates and nonaffiliates. It is also important to build upon interview approaches. A

better understanding of faculty and center affiliate role strain may require multiple methods, perhaps a mix of intensive case studies; structured questionnaires administered to large, representative samples; and additional in-depth interviews.

Our study provides evidence of role strain. Our conjecture is that role strain, despite the recompense of added resources, sometimes takes a toll on the individual faculty researcher as well as on the supervisors who must adapt to the multiple allegiances and crosscutting duties of their charges. University centers have provided much institutional innovation. Perhaps it is now time to focus a bit more on the personnel management and policy issues those innovations have spawned.

APPENDIX

Below is the semistructured protocol we used for our interviews of university scientists with dual allegiances to departments and centers. We developed the protocol based on a previous study during which we interviewed mostly MMURC directors, though some bench faculty as well (Bozeman & Boardman, 2003).

Incentives (1)

1. Tell me how you came to affiliate with the center.

Probes:

- How did you become aware of the center? Were you aware of it when you joined the university?
- How did you become interested in working for the center? Did you join the university because of the center?
- Who was instrumental in your joining the center? Did you approach the center or did the center approach you?
- Do you expect to continue with the Center? Has your level of interest in working with the Center increased or decreased during the past year?

Incentives (2)

14. This is the last set of questions. I am going to read for you a list of reasons some research have given us for working in a university research center in addition to an academic department. Please indicate the extent to which you agree with each of the following statements. (1 = Strongly Agree, 2 = Agree Somewhat, 3 = Disagree Somewhat, 4 = Strongly Disagree)

- A. I work in a center because it allows me to choose the direction of my own research. (Autonomy)
- B. I work in a center because of my personal commitment to being a scientist. (Commitment)
- C. I work in a center because it allows me to publish my research results. (Disciplinary Communism)
- D. I work in a center because of the social benefits that center science provides to society. (Humanitarianism)
- E. I work in a center because of the access to equipment and labs. (Resources)
- F. I work in a center because it provides access to students. (Resources)

APPENDIX (*Continued*)

- G. I work in a center because it provides access to other scientists outside my department. (Resources)
- H. I work in a center because it provides access to scientists at other universities. (Resources)
- I. I work in a center because it provides access to industry. (Resources)
- J. I work in a center because it provides access to other scientists at federal laboratories or agencies. (Resources)
- K. I work in a center because of access to research funds. (Resources)
- L. I work in a center because it is prestigious. (Prestige)
- M. I work in a center because I am interested in starting my own company. (Entrepreneurialism)
- N. I work in a center because I may want to work in industry. (Entrepreneurialism)

Activities

2. I am going to list for you activities that some center faculty have indicated (in previous interviews) that they perform for their centers.

- A. Do you submit research findings for publication? ___Yes ___No
- B. If you can distinguish research from the center and research for the academic department, do you submit to the center research to different journals? Cannot Distinguish ___ Yes ___ No

B. Do you mentor students who are working at the center? ___Yes ___No

Probes:

- How many total?
- How many are from a different academic department than your own?

C. Do you perform or participate in administrative duties for the center? Including such duties as participating in committees, administering grant proposals or working on annual reports? ___Yes ___No

Probes:

- Please describe what these duties entail.
- Committees?
- Annual reports?
- Grant proposals?
- Conference prep?
- Hosting evaluators?

D. As part of our center work do you interact with industry? ___Yes ___No

Probes: Do you meet or communicate with industry partners to:

- At all?
- Present research results?
- Implement research results?
- Provide technical assistance?
- Plan new projects?
- Solicit feedback on your research?
- Assess industry needs?
- Provide access to equipment?
- Provide career or internship opportunity for your students?
- Because you have to?

APPENDIX (*Continued*)

E. Do you work on grants or grant proposals that are administered by the center or use center resources? ____ Yes ____ No

- Are these grants wholly with the center or shared with your academic department?
- Is part of your salary paid by center grants?
- Are you a principle investigator on any center grants?

Rewards

3. Does your department encourage or discourage you to work with the center? Just speaking generally, can you tell me how your department recognizes, rewards, or punishes the work you conduct in your center.

Probes:

- That gives some general insight, can you tell me about any recent incident in which you were either particularly pleased or displeased about your department's response to your center work?
- VITAL QUESTION, get respondent talking.

[NEW QUESTION] Let's consider the same question from the other perspective. Do the people with whom you work at the center adequately recognize and appreciate the work you must do for your academic department?

[same follow up—recent incident]

4. Do you feel that working in the center enhances your ability to publish in academic journals?

Probes:

- Are these journals the same journals that your department expects you to publish in?
- If not, does your department acknowledge your center-based publications in the same manner as they acknowledge your department-based publications?

5. Could you tell me how your department responds, either (1) positively, (2) negatively, or (3) with ambivalence or not at all to each of the following work WITH THE CENTER? (ASK ONLY ABOUT THOSE TASKS THAT THEY INDICATED THEY PERFORMED IN THE CENTER ABOVE.)

A. Publications ____ positively ____ negatively ____ ambivalence or neither

Probes:

- Please explain.
- (ASK ONLY IF THEY PUBLISH IN "NONDEPARTMENT" JOURNALS) If negative, do you think it is because your center publications are not in the journals your department value most?
- If positive, are these publications in the journals that your department values most?
- How, if at all, does your department reward you for these publications?
- Do these publications "count" as much as non-center publications?
- Do publications in the journals that your department values most "count more" than your center-based publications?

B. Mentoring students who are not members of the academic department ____ positively ____ negatively ____ ambivalence or neither

APPENDIX (*Continued*)

Probes:

- Please explain.
- (ASK ONLY IF THEY MENTOR “NONDEPARTMENT” STUDENTS) Does it matter if the student belongs the department?
- How, if at all, does your department reward you for mentoring center affiliated students?

C. Center administration and committee work ____ positively ____ negatively ____ ambivalence or neither

Probes:

- Please explain.
- Does the department reward you for performing these duties? If so, how?

D. Center grants ____ positively ____ negatively ____ ambivalence or neither

Probes:

- Does your center-based grant money “count?” Does the department give you credit (towards promotion, etc) for acquiring this research money?
- If center grants do indeed “count,” does the department give it equal credit when compared to the credit that a PI-based grant going directly to the department gets? That is, is a center-based grant dollar equal to a PI-based grant dollar? Or is there an “exchange rate?”

E. Working with industry when there is no linkage to the academic department ____ positively ____ negatively ____ ambivalence or neither

Probes:

- Please explain.

6. What other center work, if any, does your department acknowledge, reward, or punish?

7. Regardless of whether your department supports your center affiliation in any other way, does your academic department consider your affiliation with the center prestigious?

Role strain – “Inter-sender” role conflict (increased workload)

8. From what you’ve told me so far, it seems possible that your center affiliation has INCREASED YOUR REGULAR AMOUNT OF WORK. Let’s consider how you allocate your time for a regular work week. (If they have worked for the center ever since joining their department, ask about their work before taking their current position in the university).

While I recognize that it is not always possible to be precise about work time estimates, could you give me your best approximation about the number of hours you spend each week on the following activities for, respectively, the department and the center? On average, how many hours per week (actual hours, not percentages) do you spend performing

- Administrative duties: ____Center ____Department
- Teaching: ____Center ____Department
- Student mentoring: ____Center ____Department
- Article writing: ____Center ____Department
- Research: ____Center ____Department
- Grant writing: ____Center ____Department

APPENDIX (*Continued*)

- Industry contact: ____Center ____Department
- Non-industry collaboration (e.g., other universities): ____Center ____Department

Role strain – “inter-role” role conflict

9. Now I'd like to ask you about the relationship of your center responsibilities to your department responsibilities. To what extent do you agree with the below statements? (1 = Strongly Agree, 2 = Agree Somewhat, 3 = Disagree Somewhat, 4 = Strongly Disagree)

- A. My center research and department research are sufficiently separate that I can easily distinguish between them.
- B. The articles I publish from my center research are separate and distinct from those I publish from my department research.
- C. With respect to the grants that support my research, I can easily distinguish the department grants from the center grants.
- D. I can distinguish between the department students that I mentor and advise and the center students that I mentor and advise.
- F. Interacting with industry is a center, not a departmental, expectation.
- G. Collaborating with people at other universities is a center expectation not a departmental one.
- H. As a result of my center affiliation, I feel that I have more research collaborators than I would if I worked only in my academic department.

10. Give me an idea of your department's expectations for your job. What is expected of you on a daily basis? As a teacher? As an administrator? As a researcher?

Probes:

- Are there any expectations that you are unsure of, any that are vague or ambiguous?
- Do you ever feel these expectations are incompatible?
- Unrealistic?
- Are these expectations additive or competing?

11. Similarly, please give me an idea of your center's expectations for your job. What is expected of you on a daily basis? As an industry contact? As an administrator? As a mentor to students? As a researcher?

Probes:

- Are there any expectations that you are unsure of, any that are vague or ambiguous?
- Do you ever feel these expectations are incompatible?
- Unrealistic?
- Are these expectations additive or competing?

12. Do you ever feel that your center's and department's respective expectations of you conflict or are incompatible? If so, in what respect is there conflict or incompatibility of expectations?

Role strain—minimization

13. (ONLY ASK IF THEY ACKNOWLEDGE ROLE STRAIN) Have you developed any particular approaches to dealing with competing expectations? For example, some people are careful about which office or lab they are in at what time, others are careful about choosing research topics that will pay-off for both the center and the department, and still others simply work harder, fulfilling more duties in a greater amount of time. These are just a few of the many examples that people have given us. Can you tell us about any particular approaches you have used in dealing with competing expectations?

Notes

¹We use “center” and comparable terms instead of the traditional “organized research unit” or “ORU” because the former carries more meaning for university scientists and administrators than does the latter (Stahler & Tash, 1994). However, this does not mean that we disregard studies of ORUs.

²For convenience we hereafter use the shorthand “scientists” to mean “scientists and engineers,” except in those cases where it is necessary to make a distinction.

³For a detailed history of the emergence of MMURCs in the United States, see Bozeman and Boardman (2003).

⁴The “voluntary” affiliation with MMURCs is a matter of interpretation. In many instances, there are forces at play that seem to essentially necessitate affiliation. For example, access to equipment might be denied unless one is affiliated. Nonetheless, most of the case studies we have conducted (see Bozeman & Boardman, 2003, for an overview) suggest that affiliation is in most cases voluntary, even in the strict sense of that term.

⁵The survey was conducted from fall 2003 to summer 2004 by the Research Value Mapping Program at Georgia Tech (<http://www.rvm.gatech.edu/>). It targeted tenured and tenure-track university researchers employed in doctorate-granting research extensive institutions, though for alternate research purposes some EPSCoR university and HBCU faculty were included. The sample was stratified by university, academic discipline, academic rank, and gender. The resultant sampling frame contained 4,916 individuals. The survey was executed in accordance with Dillman’s (2000) “tailored design method.” The survey was terminated with a response rate of 40%.

⁶The analytic thrust of this study is not to predict when university scientists experience role strain and when they do not. The chief value of our interview and case data is rather to use role theory and the concept of role strain to describe the phenomenon in all of its forms, the various environments in which it occurs, the different individuals it affects, and the strategies employed for mitigating it. Further analysis of institutional determinants of role strain requires additional research and is beyond the scope of the current study.

⁷We consider this evidence indirect because it relies on the assumption that perception of a negative departmental reaction necessarily translates into departmental pressure on the scientist to perform certain activities and not to perform others, resulting in inter-sender (work overload) and possibly inter-role (work incompatibility) role conflict. Moreover, this evidence presumes accurate respondent perceptions of departmental attitudes and behaviors towards MMURC activities.

⁸We use the term “volunteer” in a relative sense, when compared to classic ideas about role strain “minimization” in scientists (e.g., Goode, 1960). For scientists deciding whether to pursue a career in industry versus academe (which is the prototypical case in studies of scientific role strain that were written before the advent of the centers approach to university science), role strain is minimized if their selection represents a good “fit” in goals and values between the employer organization and employee scientists. For example, a scientist who values publishing (Merton’s “disciplinary communism,” 1957), minimizes his role strain by taking a job as a professor rather than as an industry scientist because universities value (and allow) publishing whereas private firms generally do not. Role strain derived from center affiliation is “volunteer” insofar as many, if not most, university scientists—in the case of our interviewees, all but one scientist—decide to work with an MMURC after having established oneself already in an academic department. This decision is, among other things, a decision to take on more responsibility and to perform tasks that are sometimes in contradiction to department tasks and expectations. We acknowledge that in some instances departmental pressures on scientists to procure research funds may see university scientists affiliating with centers who otherwise, in the absence of such pressures, would choose not to work in an MMURC. However, we find no such instances in our interviews.

References

- Andrews, F. (1979). *Scientific productivity: The effectiveness of research groups in six countries*. Cambridge: New York University Press.
- Arocena, R., & Sutz, J. (2001). Changing knowledge production and Latin American universities. *Research Policy*, 30, 1221–1235.
- Barber, B. (1953). *Science and the Social Order*. Glencoe, IL: Free Press.
- Biddle, B. J., & Thomas, E. J. (1966). *Role theory: Concepts and research*. Oxford, England: John Wiley & Sons.
- Blissett, M. (1972). *Politics in science*. Boston: Little, Brown.
- Blume, S. S. (1974). *Toward a political sociology of science*. New York: Free Press.
- Boardman, C., & Ponomarev, B. (2007). Reward systems and NSF university research centers: The impact of tenure on university scientists' valuation of applied and commercially-relevant research. *The Journal of Higher Education*, 78(1), 51–70.
- Bowen, W. G., & Sosa, J. A. (1989). *Prospects for faculty in the arts and sciences*. Princeton, NJ: Princeton University Press.
- Box, S., & Cotgrove, S. (1966). Scientific identity, occupational selection and role strain. *British Journal of Sociology*, 17, 20–28.
- Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.
- Bozeman, B., & Melkers, J. (1993). *Evaluating R&D impacts: Methods and practice*. Norwell, Mass.: Kluwer Academic Publishers.
- Bozeman, B., & Boardman, C. (2003). *Managing the new multipurpose, multidiscipline university research center: Institutional innovation in the academic community*. Washington, DC: IBM Endowment for the Business of Government.
- Bozeman, B., & Boardman, C. (2004). The NSF engineering research centers and the university-industry research revolution: A brief history featuring and interview with Erich Bloch. *Journal of Technology Transfer*, 29, 365–375.
- Bozeman, B., & Crow, M. (1990). The environments of U.S. R&D laboratories: Political and market influences. *Policy Sciences*, 23, 25–56.
- Bozeman, B., Dietz, J., & Gaughan, M. (2001). Scientific and technical human capital: An alternative model for research evaluation. *International Journal of Technology Management*, 22, 636–655.
- Braxton, J. M., & Del Favero, M. (2002). Evaluating scholarship performance: Traditional and emergent assessment templates. *New Directions for Institutional Research*, 114, 19–31.
- Brooks, H. (1978). The problems of research priorities. *Daedalus*, 107, 171–190.
- Colbeck, C. (1998). Merging in a seamless blend: How faculty integrate teaching and research. *Journal of Higher Education*, 69, 647–671.
- Crow, M., & Bozeman, B. (1987). R&D laboratories' environmental contexts: Are the government lab-industrial lab stereotypes still valid? *Research Policy*, 13, 329–355.
- Crow, M., & Bozeman, B. (1998). *Limited by design: R&D laboratories in the U.S. national innovation system*. New York: Columbia University Press.
- Diamond, R. M. (1993). Instituting change in the faculty reward system. *New Directions for Higher Education*, 81, 13–22.

- Diamond, R. M. (1999). *Aligning faculty rewards with institutional mission: Statements, policies, and guidelines*. Bolton, MA: Anker.
- Dillman, D. A. (2000). *Mail and internet surveys: The tailored design method* (2nd ed.). New York: J. Wiley.
- Dooris, M. J., & Fairweather, J. S. (1992). *The organization of academic research: Faculty behavior and perceptions*. East Lansing, MI: Association for the Study of Higher Education.
- Etzkowitz, H. (1998). The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. *Research Policy*, 27, 109–123.
- Etzkowitz, H., Webster, A., Gebhardt, C., & Cantisano Terra, B. R. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, 29, 313–330.
- Evan, W. (1962). Role strain and the norm of reciprocity in research organizations. *The American Journal of Sociology*, 68, 346–354.
- Faia, M. (1980). Teaching, research and role theory. *Annals of the American Academy of Political and Social Science*, 448, 36–45
- Fairweather, J. S. (1996). *Faculty work and public trust: Restoring the value of teaching and public service in American academic life*. Boston: Allyn and Bacon.
- Fairweather, J. S. (2005). Beyond the rhetoric: Trends in the relative value of teaching and research in faculty salaries. *The Journal of Higher Education*, 76, 401–422.
- Fisher, C., & Gitelson, R. (1983). A meta-analysis of the correlates of role conflict and ambiguity. *Journal of Applied Psychology*, 68, 320–333.
- Friedman, R. S., & Friedman, R.C. (1982). *The role of organized research units in academic science*. Washington, DC: National Science Foundation.
- Fulton, O., & Trow, M. (1974). Research activity in American higher education. *Sociology of Education*, 47, 29–73.
- Gaughan, M., & Bozeman, B. (2005). *Impacts of university research centers on graduate education*. Paper prepared for the Triple Helix Conference, Turin, Italy.
- Geiger, R. L. (1990). Organized researchers unite—their role in the development of university research. *Journal of Higher Education*, 61, 1–19.
- Geisler, E. (1989). University-industry relations: A review of major issues. In A. N. Link & G. Tassej (Eds.), *Cooperative research and development: The industry-university-government relationship* (pp. 43–64). Boston: Kluwer.
- Gieryn, T. (1983). Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *American Sociological Review*, 48, 791–795.
- Goode, W. J. (1960). A theory of role strain. *American Sociological Review*, 25, 483–491.
- Hagstrom, W. (1965). *The scientific community*. New York: Basic.
- Hampel, R. L. (1995). Overextended. *Educational Researcher*, 24, 29–30.
- Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D., & Rosenthal, R. A. (1964). *Organizational stress*. New York: Wiley.
- Kleinman, D. L., & Vallas, S. P. (2001). Science, capitalism, and the rise of the “knowledge worker”: The changing structure of knowledge production in the United States. *Theory and Society*, 30, 451–492.

- Kornhauser, W. (1962). *Scientists in industry: Conflict and accommodation*. Berkeley: University of California Press.
- Lin, Min-Wei, & Bozeman, B. (2006). Researchers' industry experience and productivity in university-industry research centers. *Journal of Technology Transfer*, 2, 269–290.
- MacKinnon, N. (1978). Role strain: An assessment of a measure and its invariance of factor structure across studies. *Journal of Applied Psychology*, 63, 321–329.
- Marcson, S. (1960). *The scientist in American industry*. Princeton, NJ: Princeton University Press.
- Marcson, S. (1966). *Scientists in government*. New Brunswick, NJ: Rutgers University Press.
- Merton, R. K. (1957a). *On social structure and science*. Chicago: The University of Chicago Press.
- Merton, R. K. (1957b). The role-set: Problems in sociological theory. *British Journal of Sociology*, 8, 106–120.
- Owen-Smith, J. (2003). From separate systems to a hybrid order: Accumulative advantage across public and private science at research one universities. *Research Policy*, 32, 1081–1104.
- Pelz, D. C., & Andrews, F. M. (1966). *Scientists in organizations: productive climates for research and development*. New York: Wiley.
- Porter, A. L., & Rossini, F. A. (1985). Peer review of interdisciplinary research proposals. *Science, Technology, and Human Values*, 10, 109–123.
- Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. N. (2003). Commercial knowledge transfers from universities to firms: Improving the effectiveness of university-industry collaboration. *Journal of High Technology Management Research*, 14, 111–133.
- Slaughter, S., Campbell, T., Folleman, M. H., & Morgan, E. (2002). The “traffic” in graduate students: Graduate students as tokens of exchange between academe and industry. *Science, Technology and Human Values*, 27, 282–313.
- Smith, B. L. R., & Karlesky, J. (1977). *The state of academic science*. New York: Change Magazine Press.
- Stahler, G. J., & Tash, W. R. (1994). Centers and institutes in the research university: issues, problems, and prospects. *The Journal of Higher Education*, 65, 540–554.
- Van Sell, M. T., Brief, A., & Schuler, R. (1981). Role conflict and role ambiguity: Integration of the literature and directions for future research. *Human Relations*, 34, 43–71.