UNIVERSITY RESEARCH CENTERS AND THE COMPOSITION OF ACADEMIC WORK

A Doctoral Dissertation
Presented to
The Academic Faculty

By

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<tr>
<td>AUTM</td>
<td>Association of University Technology Managers</td>
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<tr>
<td>CV</td>
<td>Curriculum Vitae</td>
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<td>ERC</td>
<td>Engineering Research Center</td>
</tr>
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<td>FTEs</td>
<td>Full Time Employees</td>
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<td>HBCU</td>
<td>Historically Black College and University</td>
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<td>HLM</td>
<td>Hierarchical Linear Modeling</td>
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<tr>
<td>I/UCRC</td>
<td>Industry/University Cooperative Research Center</td>
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<tr>
<td>ISI</td>
<td>Institute for Scientific Information</td>
</tr>
<tr>
<td>NCES</td>
<td>National Center for Education Statistics</td>
</tr>
<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RVM</td>
<td>Research Value Mapping</td>
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<tr>
<td>S&amp;E</td>
<td>Science and Engineering</td>
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<tr>
<td>STC</td>
<td>Science and Technology Center</td>
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<td>STHC</td>
<td>Scientific and Technical Human Capital</td>
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<td>TTO</td>
<td>Technology Transfer Office</td>
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<td>UIRs</td>
<td>University-Industry Relationships</td>
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<td>USPTO</td>
<td>United States Patents and Trademarks Office</td>
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SUMMARY

The purpose of this study is to assess the extent to which affiliation with a university research center affects how university scientists allocate their work time across their many academic tasks and responsibilities, including research, teaching, student advising, grants and contracts work, and service and committee duties. The key proposition is that institutional variation across university research centers can affect greatly how center affiliated university scientists allocate their work time insofar as some center level characteristics are more conducive than are others to “role strain,” which is the “structural circumstance” (Merton 1957) wherein an individual is beholden to center and departments norms and expectations that are divergent. The concept of role strain befits analysis of the impact of center affiliation on university scientists’ time allocations insofar as it provides a structural framework with which to characterize the time constraints that center scientists face as a result of being dually obligated to a center and an academic department. Moreover, study at the organizational level of analysis emphasizes competition and even conflict between university research centers and academic departments over the scarce resource of faculty time (Geiger 1990, Stahler & Tash 1994, Mallon 2004).

This study uses data from a national survey of university scientists as well as data from interviews with university scientists who affiliate with National Science Foundation Engineering Research Centers or Science and Technology Centers. Survey results demonstrate that a center’s size, “multidisciplinarity,” organization within the university, programmatic ties, and external relations increase the time allocated to research, grants
and contracts work, and service and committee duties. These findings constitute “objective” evidence of center induced role strain (Pandey & Kumar 1997, Rizzo et al. 1970) insofar as they identify components of center scientists’ work environments suggestive of center and department norms and expectations being divergent and even conflicting. Interview results demonstrate similarly that when a center has no ties to an academic department and when its research focus is applied or commercially relevant, workload increases. These findings constitute “subjective” evidence of center induced role strain (Pandey & Kumar 1997, Kahn et al. 1964) insofar as it is the center scientists themselves observing these divergent norms and expectations.

Implications for policy and theory are discussed.
1. INTRODUCTION

The expectations of university based science and engineering in the U.S. have changed dramatically over the past thirty years. Whether one considers the “social contract” for science to be broken, intact but altered, or something else all together, during the 1970s and early 1980s social and political concern about American science fostered a climate conducive to the establishment of new university based “boundary organizations.” Many of these organizations formed in response to calls for increased productivity and integrity in American science (Guston 2000). Others formed in response to the call for enhanced competitiveness in the global marketplace (Geiger 1990). Even after such calls quieted and American science became more accountable and once again situated at the forefront of scientific and technical innovation (from the late 1980s through the 1990s), new institutional forms continued to emerge on university campuses, particularly due to the increasing complexity and expense of scientific and technical research (Ziman 1994).

Changed expectations and the institutions that resulted helped to create new roles for university scientists and engineers. Technology licensing offices provided the expertise and resources necessary for university scientists to act as entrepreneurs and explore the commercial potential of their projects. Research parks, by bringing science and technology based firms in close proximity to university campuses, enabled university

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1 Organizational theorists generally support the notion of social and political environments, along of course with available resources, converging to see the formation of new organizations that are more responsive to contemporaneous demands and values than are existing organizations (e.g., Baum & Powell 1995, Delacroix & Rao 1994, Hannan et al. 1995).

2 For convenience I hereafter use the shorthand “scientists” to mean “scientists and engineers” except in those cases where it is necessary to make the distinction.
scientists to act as consultants and “transfer agents” (Bozeman 2000). Offices of research integrity encouraged university scientists to act as proctors and ethicists, helping them to understand and adhere to the laws, regulations, and policies to which they are subject.

The most prevalent “post contract” university based institution is the contemporary university research center or “organized research unit” (Friedman & Friedman 1982). According to the Research Centers Directory, there are more than 14,000 university research centers in the U.S. Large universities often have more than sixty centers, some have as many as two hundred (Hays 1991, Dresser 1989). Perhaps the best known university research centers are those associated with the National Science Foundation (NSF), including Engineering Research Centers and Science and Technology Centers, which focus on research topics rather than disciplines, implement strong interinstitutional and cross sector ties, and play a major role in the conduct of “big science” in the U.S. (Bozeman & Boardman 2004).

As with the aforementioned institutions, university research centers first and foremost were intended to induce in university scientists behaviors typically not encouraged in the traditional university context of academic departments. Though they can vary greatly across a number of attributes (Stahler & Tash 1994), centers generally facilitate on the part of university scientists the conduct of multidisciplinary or

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3 I use “university research center” and the abbreviated “center” instead of the traditional “organized research unit” or “ORU” in that the former carries more meaning for university scientists and administrators than does the latter (Stahler & Tash 1994). However, this does not mean that in my analysis I disregard studies of ORUs.

4 This database is managed by the Dialog Corporation and was last loaded June 1, 2006 (http://library.dialog.com/bluesheets/html/bl0115.html). I called Dialog’s parent company, Thomson Gale, to ask a sales representative about how the quantity 14,000 was derived. After referring me to a “technical” assistant, I was told that for an organization to qualify as a university based research center, it must be affiliated with a university and it must conduct research. The person I talked to could not answer questions about whether academic departments were counted, whether an organization had to be “university based” or merely affiliated with a university, and so on. Therefore, I suspect that 14,000 may be an overestimate.
interdisciplinary (Ikenberry & Friedman 1972) and problem focused (Bozeman & Boardman 2003) research amenable to application in addition to (or perhaps instead of) publication.

In promoting such conduct, university research centers have been shown to provide numerous benefits. They aid industrial partners, if they have them, by way of increased patenting and research (Adams et al. 2001), enhanced access to students for potential hire (Feller & Roessner 1995), enhanced access to “upstream” modes of knowledge (Feller et al. 2002), and also by way of technological problem solving and competency building (Santoro & Chakrabarti 2002). Centers benefit the university scientists who affiliate with them as well, through increased opportunities for research (Corley & Gaughan 2005), enhanced access to industrial research partners (Bozeman, forthcoming), enhanced access to resources (including funds, equipment and infrastructure, and collaborators), and also by offering an opportunity to “do good” for society (Friedman & Friedman 1984).

However, while new institutional forms and the roles (and attendant behaviors) they facilitate indeed can provide benefits, they can also disrupt (Schabracq & Cooper 2000). The titles of recent studies of academic science suggest the dynamic and disruptive nature of universities’ changes in institutional design. Etzkowitz and colleagues (2000) examine the “evolution of the ivory tower to entrepreneurial paradigm;” Slaughter and colleagues (2002) speak of “trafficking” in graduate students and examine “graduate students as tokens of exchange between academe and industry;” Owen-Smith (2003) notes 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.

University research centers “disrupt” by making the workaday lives of the university scientists who affiliate with them more complex and perhaps even more difficult (than the workaday lives of department based “non center” scientists). Center scientists’ lives are more complex because, in affiliating with centers, these scientists take on a role that constitutes (potential) extra demand for their time and energy in addition to extant demand emanating from their academic departments. In many instances center scientists must perform “double duty” per their respective center and departmental assignments (Bozeman & Boardman 2003, p. 29). Center scientists’ workaday lives are more difficult due to (potential) competition and even friction between centers and departments over the scarce resource of faculty time. Geiger (1990) describes center-department relations as “tension-prone and symbiotic” in his discussion of the “dual orientation” of center affiliated university scientists (p. 10). Stahler and Tash (1994) cite center-department clashes over not just faculty time, but also over internal funding support, space, equipment and research infrastructure, and credit for grants and for research outputs.

The dual obligation to center and department can mean for center scientists dual sets of perhaps similar though no less distinct responsibilities, which in turn can enhance for these scientists what sociologists and psychologists have long called “role strain” (Goode 1960) or “role conflict” (Kahn et al. 1964). Role strain occurs when an individual is subjected to two or more sets of demands or expectations (e.g., one from a center and one from a department) such that compliance with one set of demands renders
compliance with the another set more difficult or perhaps even impossible (Pandey & Kumar 1997). Role strain is common already within academic departments (Bowen & Sosa 1989), which expect of university scientists multiple behaviors that sometimes compete or conflict, such as teaching and research (Shapiro 1978). University scientists who obligate to meet simultaneously the demands and expectations of both academic departments and university research centers run the risk of experiencing added role strain because, in most cases, centers are distinct from departments in terms of mission and practice, organization, among other characteristics (Ikenberry & Friedman 1972). Accordingly, center affiliation does not reduce one’s commitment to committee meetings, it expands it; it does not limit the time one must devote to mentoring students, it increases it; it does not simplify one’s research and technology portfolio, it makes it more diverse (Bozeman & Boardman 2003).

Study of the impact of new institutional forms on behavior usually focus on the “new” behaviors that those forms are designed to induce. A majority of empirical work on university research centers addresses the benefits industry derive from partnering with centers. Understudied though not unstudied (e.g, Corley & Gaughan 2005, Gaughan & Bozeman, forthcoming) is the impact that centers have on the workaday activities of

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5 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. I prefer the role strain label inasmuch as conflict often implies active disagreements among parties whereas role strain generally pertains to perceptions of individuals occupying a particular role. Generally, role strain refers to the circumstance in which individuals are subject to competing demands in the workplace, in the home, or elsewhere.

6 Before using the concept of role strain to describe and explain the (potential) impact of center affiliation on university scientists, it is important to clarify what the concept is intended to describe and explain and what it is not. As stated above, the focal point of the role strain concept is the difficulty “getting things done” an individual perceives or experiences when fulfilling simultaneously more than one set of role obligations, in this case one set for a university research center and another set for an academic department. The concept, at least in its conventional application and especially in its application to scientists as well as to organizations, is not intended to describe or explain the emotive stress or any other psychological effect incurred by this individual (Biddle 1979). I discuss this further in the next section of this chapter.
university scientists. Because there is “functional overlap” (Biddle 1979) between the behaviors expected of scientists by centers and by academic departments, for instance both expect scientists to conduct research, affiliation with a center may alter the way university scientists spend their work time in unforeseen ways.

The purpose of this study is to assess the extent to which affiliation with a university research center affects the composition of university scientists’ academic work. “Composition of academic work” entails how university scientists allocate their work time across their many academic tasks and responsibilities, including research, teaching, student advising, grants and contracts work, and service and committee duties. Faculty time is a key university resource, and how professors use their time has come under public scrutiny regarding increased fiscal constraints and increased pressures to enhance teaching (Jacobs & Winslow 2004). Though issues regarding time allocation in general have received attention in the economics literature (e.g., Juster and Stafford 1991), what few studies of the way university scientists allocate their time exist have been largely descriptive (e.g., Yuker 1984, Bunnell 1960).

The key proposition of this study is that institutional variation across university research centers can affect greatly how center affiliated university scientists allocate their work time insofar as some center level characteristics are more conducive than are others to “role strain,” which has been demonstrated empirically to increase workload in occupational settings (MacKinnon 1978, Biddle 1979) and has recently been applied in numerous studies to assess the tensions and conflicts associated with membership in organizations (Pandey & Kumar 1997). Emphasis on the concept of role strain befits analysis of university scientists insofar as university scientists are already considered to
experience role strain within the context of academic departments to perform numerous and sometimes competing roles, such as those of teacher, administrator, colleague, researcher, and so on (Bowen & Sosa 1989). The concept of role strain in particular befits analysis of the impact of center affiliation on university scientists’ time allocations insofar as study at the organizational level of analysis emphasizes competition and even conflict between university research centers and academic departments over the scarce resource of faculty time (Geiger 1990, Stahler & Tash 1994, Mallon 2004).

The findings of this study raise important questions regarding the management practices of university research centers, including the formal and informal connections centers make (or do not make) to other units in the university, including but not limited to academic departments. Closely related are questions regarding the extent to which center work may or may not “count” in departmental tenure and promotion decisions. From a much broader perspective, the results suggest that “academic capitalism” (Slaughter & Leslie 1997) may have short run in addition to long run impacts worth consideration by both universities and policy makers.

The next section of this chapter reviews in detail the analytical framework for examining the role strain individuals experience when they take on multiple and conflicting roles, known as role theory, which has had broad application in the social sciences.7 In this section I review how the center and department (as well as other) roles “operate” to influence center scientists’ behaviors and how an obligation to fulfill these roles simultaneously may lead a center scientist to experience one or more “dimensions” of role strain (Pandey & Kumar 1997). While this discussion is limited mostly to

7 Biddle (1986) observed that more than ten percent of all articles published in sociological journals employed the role concept and that “endless applications” of “role ideas” could be found in the literature and in textbooks for sociology, social psychology, and anthropology (p. 67-68).
discussion of “center induced role strain,” other sources of strain are discussed, including that related to tenure status. The following section of this chapter appeals to the need for a better account of university research centers that considers how different one center can be from the next. The way a center relates (or not) to other academic units in its home university, the number of disciplines represented by a center’s faculty membership, the types of external stakeholders to which center scientists are beholden, and numerous other characteristics all can affect whether or not scientists experience role strain as a result of center affiliation.

The “strained” roles of center scientists

In their use of confirmatory factor analysis to identify the numerous “dimensions” of the role strain concept, Pandey and Kumar (1997) cite as their motivation for doing so the “increased interest in the use of role theory to describe and explain the tensions and conflicts associated with membership in organizations” (p. 187). Perhaps more than members of other professions, scientists who are university faculty members run the risk of experiencing “tensions and conflicts” due to their involvement in multiple missions. In the academic department alone, scientists are expected to teach, conduct research, mentor students, sit on hiring committees, among numerous other responsibilities. More related to the topic of centers and the scientists they share with academic departments, the traditional academic reward template’s emphasis on research (Braxton & Del Favero 2002) and the increasing expense of this activity in a climate of (near) steady state

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8 Pandey and Kumar actually use the term “role conflict” rather than the term “role strain,” but no less use items from scales of both “role conflict” and “role strain” in their analysis. Essentially the terms “role strain” and “role conflict” are substitutes. I prefer the role strain label inasmuch as conflict often implies active disagreements among parties whereas role strain generally pertains to perceptions of individuals occupying a particular role. Generally, role strain refers to the circumstance in which individuals are subject to competing demands in the workplace, in the home, or elsewhere.
funding (Ziman 1994), when taken together, sees many university scientists acting as “academic capitalists” (Slaughter & Leslie 1997) by making as many alliances as are required to procure the funding and access to the equipment, collaborators, and other resources that give them the research capacity (Bozeman et al. 2001) they need to be productive scientists. The modern day professoriate includes many opportunities for role strain, more perhaps than it ever has. But what does this mean? What roles do university scientists play and when do they experience role strain? How can this strain be measured and what are its outcomes?

Within the traditional context of the university, the term “role” may be defined as a set of expectations applied to a scientist occupying a faculty position in an academic department by the individual scientist herself and also by others (e.g., colleagues, administrators, students) both inside and outside the organizational boundaries of the department. As role theory suggests that individuals are frequently confronted (Merton 1957, Goode 1960, Kahn et al. 1964) with circumstances wherein they are required to play a role which conflicts with their value systems or to play multiple roles which conflict with each other or which expect incompatible behaviors and derive from one or more sources, it seems reasonable to suggest that scientists who are faculty members in academic departments who additionally affiliate with university research centers have a greater chance of experiencing role strain than have scientists who do not make the same dual obligation.

The potential for role strain, moreover, is amplified or perhaps even qualitatively changed when one considers not just a university scientists’ dual affiliation to center and department, but also the many other characteristics of faculty life that represent the
additional roles that university scientists may fulfill. Consider briefly the example of tenure status. When a university scientist has it, she may react to the department expectation to conduct administrative duties much differently than she did when a junior level scientist, she may react differently to center expectations to conduct research that is not valued in the department than she did when junior level, and so on.

Before considering how role strain “operates” and leads to outcomes including but certainly not limited to altered time allocations, there are numerous “dimensions” of the role strain concept to consider, not all of which apply to the central operation of this study, “center induced role strain.” In discussing the dimensions of role strain I specify which apply to the current study and in what conceptual form. I also discuss the data used to demonstrate the occurrence of particular dimensions role strain as well as how the numerous roles fulfilled by university scientists interact with one another within the larger system of roles (called the “role set”) that constitutes the “meta profession” of the professoriate (Arreola et al. 2003).

Dimensions of role strain

Perhaps because most studies using the role strain concept use it to highlight the dimensions of a practical problem rather than to refine the concept or to extend or amend role theory in any meaningful way (Biddle 1979, Biddle 1986), most studies of role strain, even very recent studies, rely on the classic definitions of the concept, particularly Goode’s (1960) “…felt difficulty in fulfilling role expectations” (p. 483) and Merton’s (1957) “structural circumstance that anyone occupying a particular status has role partners who are differently located in the social structure” (p. 370-71). More recent and

---

9 The same dimension may be conceptualized either “objectively” or “subjectively” (Pandey & Kumar 1997). I discuss this at length below.
equally close to how the concept is employed in this study is Pandey and Kumar’s (1997) definition of role strain as a “state of mind or experience or perception of the role incumbent arising out of the simultaneous occurrence of two or more role expectations such that compliance with one would make compliance with the other(s) more difficult or even impossible” (p. 190). It is important to note that these definitions speak to the relationship between the different demands and expectations an individual faces (e.g., if the demands and expectations complement one another, if they contradict one another) and not to any emotive stress or “strain” that an individual may experience as a result of the relationship. As Merton (1957) first put it, role strain is a “structural circumstance.”

There have been identified in the sociology and psychology literatures numerous dimensions of role strain. These dimensions identify the source(s) of the strain as well as the substantive nature of the strain. There are also intra dimensional distinctions to make between “objective” role strain, which is an observable component of an individual’s environment and/or situation that is conducive to role strain, and “subjective” role strain, which is an individual’s report of experiencing or having experienced role strain (Kahn et al. 1964). Pandey & Kumar (1997) identify four dimensions of role strain, based upon their review of major studies of the topic. Drawing from Kahn and colleagues (1964), Rizzo and colleagues (1970), and from King and King (1990), among others, the authors distinguish between intra sender, inter role, inter sender, and person-role dimensions of role strain as well as between the objective and subjective conceptualizations of each dimension.
Table 1. Dimensions of role strain

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<th>Description and example</th>
<th>Conceptualization</th>
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<tr>
<td>“Intra sender” role strain</td>
<td>This is experienced when a single role sender harbors incompatible expectations of an individual. An example is when a supervisor expects a subordinate to uphold company policies while at the same time expecting the subordinate to perform a task that is prohibited by these policies.</td>
<td>Objective and subjective</td>
</tr>
<tr>
<td>“Inter role” role strain</td>
<td>This is experienced when an individual faces expectations in one role that are incompatible with the expectations she faces in another role. An example is when a university scientist faces expectations from a department to create new knowledge and faces from a center expectations to apply existing knowledge to a practical problem.</td>
<td>Objective and subjective</td>
</tr>
<tr>
<td>“Inter sender” role strain</td>
<td>This is experienced when an individual faces expectations from more than one role sender. The expectations of each sender may or may not conflict. An example is when a university scientist faces expectations from a department to fulfill a full workload and an additional expectation from a center to fulfill another, distinct workload.</td>
<td>Objective and subjective</td>
</tr>
<tr>
<td>“Person-role” role strain</td>
<td>This is experienced when an individual faces expectations that are incompatible with her values. An example is when an untenured scientist is required to conduct research that is not amenable to outputs that will help her attain tenure status.</td>
<td>Subjective</td>
</tr>
</tbody>
</table>

Source: Adapted from Pandey & Kumar (1997), King & King (1990), and Kahn et al. (1964).

The table briefly describes the four major dimensions of role strain. The idea of center induced role strain draws predominantly from the “inter sender” and “inter role” dimensions of the role strain concept. Inter sender role strain contributes to the idea of center induced role strain because in center affiliation, center scientists become beholden to two distinct role senders, the center and the department, each which harbors its own expectations of the scientist and each which demands that the scientist allocate time and energy towards meeting those expectations. Inter sender role strain may be conceptualized as an “objective” (e.g., Kahn et al. 1964) and/or as a “subjective” (e.g., Rizzo et al. 1970) phenomenon (Pandey & Kumar 1997). The objective measurement of inter sender role strain can include, among other concepts (e.g., Berger-Gross & Kraut 1984, Dougberry & Pritchard 1985), the identification of an individual’s obligation to
meet the expectations of distinct role senders (Biddle 1979, Kahn et al. 1964). In this way the measurement of role strain seems more a measure of potential role strain than a direct measure thereof. More direct, the subjective measurement of inter sender role strain can include reports of felt difficulty in fulfilling role obligations from individuals with multiple obligations (Biddle 1979).

It is important to note that in the above table the description of the inter sender dimension of the role strain concept is closer to that of Kahn and colleagues (1964) than it is to that of later descriptions (e.g., Pandey & Kumar 1997) insofar as the description does not logically preclude the occurrence of the “inter role” dimension of role strain (as precludes, for example, the Pandey and Kumar description). “Inter role” role strain contributes to the idea of center induced role strain because the academic department and university research center to which the center scientist is dually beholden may expect the conduct of activities that are incompatible with one another. For instance, while a department may encourage the publication of research in peer reviewed media, a center may request a delay in publication due to the proprietary implications of the same research. Like the inter sender dimension of the role strain concept, the inter role dimension may be conceptualized indirectly or objectively as an observable component of the center scientist’s work environment or directly or subjectively as a center scientist’s report of felt difficulty in meeting center demands and expectations.

Pandey and Kumar’s (1997) conceptualization of inter sender role strain limits its occurrence to a singular work role (intra role) rather than allowing it to occur as a result of fulfilling multiple work roles (inter role). Whereas most professions may be characterized by a single work role, the professoriate has been characterized as a “meta
profession” with practitioners, university scientists, who must perform numerous roles that oftentimes compete or conflict with one another (Arreola et al. 2003). Accordingly, the Pandey and Kumar (1997) constraint does not apply as well as applies the conventional conceptualization of the inter sender dimension that allows for “overlap” between the inter sender and inter role dimensions of the role strain concept (e.g., Kahn et al. 1964). When center scientists are expected to meet incompatible expectations (the inter role dimension), this incompatibility may derive from distinct role senders (i.e., the inter sender dimension) that are equally “work related” (e.g., the center and the department) as well as from just a singular work related role sender.10

The next table is a reproduction of the previous table but with additional information, including (A) whether or not the role strain dimension is used in this study to help conceptualize the operation of “center induced role strain,” (B) if used, how the dimension is conceptualized (i.e., “objectively” or “subjectively”), and (C) if used and conceptualized, what data are employed to operationalize the dimension.

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10 Though the Pandey and Kumar (1997) conceptualization of inter sender role strain does not apply well to the relatively modern scenario in which university scientists are beholden to multiple academic units that compete over faculty work time, early studies of scientists using the concept of role strain do not cross the boundaries of this constrained version of the dimension. The social study of scientists has focused almost entirely on inter sender role strain that is also intra role, for scientists working in private firms (e.g., Roe 1951, Kornhauser 1962, Hagstrom 1965, Box & Croton 1966, Perrow 1970, Rothman & Perrucci 1970) and also for scientists working in academic departments (Lacognata 1965, DeVries 1975, Shapiro 1978, Copur 1990, Fairweather 1996, Bowen & Sosa 1989, Geisler 1989, Boyer 1990, Diamond 1993, Diamond 1999, Braxton & Del Favero 2002, Fairweather 2005).10
Table 2. Dimensions of role strain related to “center induced role strain”

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description and example</th>
<th>Conceptualization:</th>
<th>Applies to the current study</th>
<th>Data used</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Intra sender” role strain</td>
<td>This is experienced when a single role sender harbors incompatible expectations of an individual. An example is when a supervisor expects a subordinate to uphold company policies while at the same time expecting the subordinate to perform a task that is prohibited by these policies.</td>
<td>X</td>
<td>X</td>
<td>No</td>
</tr>
<tr>
<td>“Inter role” role strain</td>
<td>This is experienced when an individual faces expectations in one role that are incompatible with the expectations she faces in another role. An example is when a university scientist faces expectations from a department to create new knowledge and faces from a center expectations to apply existing knowledge to a practical problem.</td>
<td>X</td>
<td>X</td>
<td>“Subjective” (Kahn et al. 1964) and “objective” (Rizzo et al. 1970)</td>
</tr>
<tr>
<td>“Inter sender” role strain</td>
<td>This is experienced when an individual faces expectations from more than one role sender. The expectations of each sender may or may not conflict. An example is when a university scientist faces expectations from a department to fulfill a full workload and an additional expectation from a center to fulfill another, distinct workload.</td>
<td>X</td>
<td>X</td>
<td>“Subjective”</td>
</tr>
<tr>
<td>“Person-role” role strain</td>
<td>This is experienced when an individual faces expectations that are incompatible with her values. An example is when an untenured scientist is required to conduct research that is not amenable to outputs that will help her attain tenure status.</td>
<td>X</td>
<td>“Subjective”</td>
<td>Interviews</td>
</tr>
</tbody>
</table>

Source: Adapted from Pandey & Kumar (1997), King & King (1990), and Kahn et al. (1964).
The inter sender dimension of center induced role strain is conceptualized subjectively (e.g., Kahn et al. 1964) as “felt difficulty in fulfilling role obligations” (Goode 1960, p. 483) that university scientists can experience when they affiliate with centers in addition to working in departments. Data from interviews with center scientists are employed to operationalize the inter sender dimension of center induced role strain.

The inter role dimension of role strain is conceptualized both subjectively and objectively (e.g., Rizzo et al. 1970). Using data from interviews with center scientists to address instances when center work is perceived as incompatible with department work, the inter role dimension of center induced role strain is conceptualized as a subjective state that may be experienced by center affiliated university scientists. Using survey data to identify center level characteristics that may represent a divergence from traditional department based academic work, such as industry relations, the inter role dimension is conceptualized objectively as observable components of an individual’s work environment that may be conducive to experiencing center induced role strain.

The row for the intra sender dimension of role strain is grayed out because it does not contribute to the idea of center induced role strain. The person-role dimension of role strain is grayed out (but lighter) because it does not constitute a major empirical component of this study, but no less it deserves mention insofar as university scientists fulfill numerous workaday roles in addition to those related to centers and departments. The person-role dimension of center induced role strain may occur when a center scientist does not value the expectations of a center, at least not as much as the center would like. Above I mentioned briefly the example of the untenured but tenure track or “junior” university scientist. The junior scientist who also is a center scientist may not
fulfill the expectations of a center in the same manner or to the same extent that a tenured scientist would, for instance, when a center’s expectations are not conducive to producing outputs that “count” in tenure and promotion decisions. When a center expects a junior scientist to consult for industry partners rather than publish, she may act as “junior scientist” rather than as “center scientist” and shirk center responsibilities in favor of conducting publishable research while a tenured scientist in the same center who is expected to perform the same industry consulting will not experience this incarnation of the “person-role” dimension of center induced role strain and therefore will not shirk center responsibilities or perhaps will shirk them, but to a lesser degree.

There can be numerous other interactions among the multiple roles of university scientists, including not just those between center affiliation and tenure status, but also, for instance, among the roles related to the “student orientation” of a scientist, the types of research agreements (via grants and contracts) the scientist is beholden to, the “cosmopolitanism” of a scientist’s collaboration patterns, and so on. However, while it is important to understand how the many roles of the professoriate interact, it is equally important to be clear about what constitutes a role and what does not, to avoid mistaking for distinguishable roles individual level characteristics that may correlate with particular types of behaviors, but no less are functional components of other roles rather than roles per se.11 The person-role dimension of role strain proves useful for explaining the way values, whether they are indicative of distinct roles or not, can alter the behaviors of scientists occupying the same roles.

11 I address how to identify and define roles (e.g., positionally, functionally, personally; Biddle 1979) in Chapter 4 below.
Before discussing how center and department roles “operate” to create for center scientists one or more of the above discussed dimensions of role strain, it is important to reiterate what “center induced role strain” means. The concept of center induced role strain, and that of role strain in general, is intended to characterize the way the center and department demands and expectations to which a center scientist is simultaneously beholden relate to one another. Are center and department demands and expectations similar? Do they conflict with one another? Do they contradict? The role strain concept, at least in its conventional application and in its application to center scientists in this study, is not intended to describe or explain the emotive stress or any other psychological effect incurred by center scientists as a result of their dual obligation to center and department (Biddle 1979). This is not to suggest that center scientists do not incur stress or other psychological effects as a result of their center affiliation. But the focus of this study is the identification of when center scientists face competing and even contradictory role expectations, either by way of “subjective” reports from center scientists themselves or by way of the “objective” observation of center level characteristics that are indicative of role strain.

**How roles “operate” to generate role strain**

To explain how center induced role strain may alter the time allocations of university scientists, one first must understand how roles “operate” and thereby influence the actions of individuals. The first operation to explain is that of a singular role. Kahn and colleagues (1964) proposed a model in which a “focal individual” and a “role sender,” which is another individual or group of related individuals who expect certain behaviors from the focal individual, interact reciprocally whereby the former satisfies the
expectations of the latter by performing expected tasks or by behaving in expected ways. Both the focal individual and the role sender(s) may be influenced by organizational factors, personality factors, and by interpersonal relations (Pandey & Kumar 1997). The expectations of the role sender that the focal individual perform expected tasks or behave in expected ways are conveyed to the focal individual by what Pandey & Kumar call “role pressures” or by what a majority of the role literature simply calls “role expectations” (Biddle 1979).

The concept of expectations is amorphous and has generated much confusion. Expectations may be norms, values, anticipations, or feelings; they may be personal, positional, or even societal; they may be spoken, written, assumed, or “covert” (Biddle 1979). Fortunately, much of the conceptual confusion is alleviated when discussing work related expectations. Per the “organizational role theory” approach, individuals working in formal organizations know what is expected of them because they are exposed to normative expectations that reflect the official demands of the organization (Biddle 1986). These norms and expectations help to create in an organization a context or environment that is conducive to the performance of expected tasks or behaviors and deterrent of the performance of alternate tasks and behaviors. Biddle (1979) uses the examples of a football game, a church sermon, and a rock concert.

“In order to know whether to cheer, to sit in solemn silence, or to applaud enthusiastically the individual must know which of these three contexts he or she has entered. He or she must be provided with a definition of the situation” (p. 6).
In this study, a center’s faculty membership and a center’s relations with external stakeholders and with centers programs are used to “define the situation” when the norms and expectations with which a center scientist is pressured to behave in expected ways by center related colleagues, superiors, and clients may be divergent from traditional academic norms and expectations, for instance when a center has industry partners or clients. In such instances, there is “objective” (or “indirect” or “contextual”) evidence of center induced role strain (Pandey & Kumar 1997, Biddle 1986, Rizzo et al. 1970).

Before describing how center and department (as well as other) demands and expectations may interact or relate in such a way as to generate within the focal individual, the center scientist, one or more of the above discussed dimensions of role strain, required is explanation of the internal functioning of roles in the center scientist. External norms and expectations, for instance those of center colleagues and center clients, cannot fully explain why the center scientist does or does not perform expected tasks or why she does or does not behave in expected ways. Equally and perhaps even more important are the notions of “identity” and “social position” (Biddle 1979) and the internal expectations of self that these notions imply. Most explications and applications of role theory seem to use the terms “social position” and “identity” interchangeably when describing these internal expectations, suggesting that an individual can have multiple identities, depending on her contemporaneous social position. For example, the same person can be a center scientist, a department faculty member, a mentor to students, and (in the case of junior level faculty) a mentee to tenured faculty.

Consider for now just one of these positions, that of center scientist. When acting as “center scientist” the focal individual is self aware of the role that she plays in the
center and harbors expectations of herself that operate quite similarly to the above discussed expectations from without (Biddle 1979). As external norms and expectations can see the center scientist acting in expected ways and performing expected tasks, so too can internal or self expectations see a similar result. When these internal expectations do not match external expectations (e.g., from center colleagues, administrators) for the same individual, the above discussed person-role dimension of role strain occurs. When these internal expectations conflict or compete with alternate internal and/or external expectations related to alternate roles, for instance those of “department scientist” or of “junior faculty member,” the inter sender and inter role dimensions of role strain may occur. This is the point when center scientists alter their behaviors as a result of center induced role strain, including how they allocate their work time across their numerous academic tasks and duties.

In the chapters that follow, I review in further detail how the inter sender and inter role dimensions of role strain help to formulate hypotheses and to guide analysis and discussion regarding how center affiliated university scientists allocate their work time across their numerous academic tasks and duties. I also include limited discussion (due to data limitations) of the person role dimension of role strain to explain how individual values associated with alternate roles, in particular those related to tenure status, may additionally influence center scientists’ time allocations. While I do not assert that center induced role strain explains entirely the observable differences in center scientists’ time allocations – for instance theories of time allocation emphasizing “gain” or increased returns predominate and, moreover, there are very important individual level
characteristics to consider – I demonstrate that for center scientists the operation of center induced role strain represents an important part of the equation.

As with most empirical applications of role concepts (Biddle 1979), in this study I do not test the key propositions of role theory in anticipation of furthering this theory in any significant or even in any minor way. I use role theory to guide my analysis of a specified science policy problem, the problem of center induced role strain.\(^\text{12}\) However, the findings have minor implications for the application of the concept of role strain to the study of scientists and also for theories of time allocation. I do not discuss these until the concluding chapter.

**Center heterogeneity and “center induced role strain”**

A fundamental assertion of this study is that university research centers are different enough from academic departments to cause role strain for university scientists who choose to affiliate with both institutional forms and that this strain affects, in turn, how these scientists allocate their work time across their academic tasks and duties. In the chapters below, I delineate two ways in which role strain can do this, per the above discussed dimensions. The first way, inter sender role strain, is simply an additive function wherein university scientists who are beholden to two (or more) distinct yet comparably legitimate role senders, the center and the department, must perform more work than must perform university scientists who are beholden to but a single, department based demand for their work time and energy. The second way, inter role role strain, is more sophisticated in that it posits additional workload not due to an added source of demand per se, but also due to the substantive nature of these additional

\(^\text{12}\) This is similar to how Guston (2000) employs principal agent theory to outline information asymmetry as the central problem of science policy writ large.
demands (Kahn et al. 1964). For instance, working with a private company on the commercial application of a new technology, while this may meet the research expectations of the center with which a university scientist affiliates, it (probably) will not meet department based research expectations.

However, depending on numerous center level characteristics, center scientists may or may not experience (as a result of center affiliation) either dimension of center induced role strain. One center can be quite different from the next (Stahler & Tash 1994). For instance, though most all centers are in practice more multidisciplinary than are departments (Ikenberry & Friedman 1972), some centers can be quite multidisciplinary while others may be comprised of faculty from but a single discipline (Bozeman & Boardman 2003). Some centers may pursue a mission of solving scientific and technical problems for industry clients while others may focus on more “basic” research (Stokes 1997) and have no ties to the private sector. Some may interact with academic departments as subunits thereof while others may be organizationally independent of departments. Some may have vast resources and infrastructure while others may exist solely on paper (or perhaps in cyberspace) as “shadow” centers (Ikenberry & Friedman 1972). Accordingly, in some instances center expectations may diverge from department expectations and cause role strain while in other instances center and department expectations may be similar or even identical, resulting in no detectable role strain.¹³

¹³ Remember the discussion in the section above. The concept of center induced role strain emphasizes how center demands and expectations relate to department demands and expectations. They may be the same or converge, in which cases role strain is non existent or minimal, or they may diverge to varying degrees, in which cases role strain occurs. Again, the focus is on the way the center and department roles (i.e., the demands and expectations from center and department) relate to one another and not on any emotive stress or “strain” that the center scientist experiences or feels as a result of role strain.
The chief proposition of this study is that because university research centers are not uniform, they do not affect center scientists’ behaviors uniformly. Heterogeneity across center characteristics, in addition to numerous other individual level factors important to predicting and explaining faculty time allocations (like tenure status, gender, discipline, total students funded, and total grants awarded), determines how center affiliated university scientists allocate their work time. Specifically, I propose that the easier can the center affiliated scientist distinguish center from department tasks for which there is “functional overlap” (Biddle 1979), such as for research and attendant administrative duties, the more time will the scientist work by allocating additional time to center based tasks in addition to that she allocates to department based tasks (MacKinnon 1978).

When center scientists can distinguish, greater is the likelihood they will experience both the inter sender and inter role dimensions of role strain. Accordingly, these scientists find themselves obligated to fulfill center and department tasks that, while functionally similar, no less are quite different and therefore require additional hours to complete. The potential for such strain and increased work load due to such strain is alleviated if the center scientist cannot distinguish between center and department tasks and duties. The potential is similarly alleviated if the center scientist does not view one set of expectations to be as “legitimate” as another and therefore has limited or no motivation to perform center related “double duty” (Bozeman & Boardman 2003).14

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14 In Chapter 5 below I discuss the many reasons center scientists view as “legitimate” the claims on their work time made by the centers with which they affiliate. In Chapters 4 and 5 I discuss other individual characteristics, such as tenure status, that may affect the perceived legitimacy of center expectations.
Study outline

I propose that center affiliation can cause role strain for center affiliated scientists and that this strain, in addition to numerous other factors, can affect how these scientists allocate their work time across their academic tasks and duties. Further, I propose that this process can be enhanced or mitigated by center level attributes, with centers that are more dissimilar than traditional academic departments enhancing the likelihood of role strain and increased workload. This argument, if I am to make it convincingly, requires that I establish the following statements (in the table as well as in italics below) to be, for want of a better phrase, “probably true.”

Table 3. Study outline

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Chapter(s)</th>
<th>Data used</th>
</tr>
</thead>
<tbody>
<tr>
<td>University research centers and academic departments are distinct in systematic ways.</td>
<td>Chapters 2 and 3</td>
<td>No data analysis. This analysis relies on extant studies of centers and departments.</td>
</tr>
<tr>
<td>Center affiliated university scientists perform distinct center and department roles.</td>
<td>Chapter 4</td>
<td>Survey data is used to demonstrate differences of time allocation means for center versus non center scientists.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interview data is used to demonstrate the extent to which center scientists can distinguish their center work from their department work.</td>
</tr>
<tr>
<td>University scientists with dual obligations to centers and departments experience center induced role strain.</td>
<td>Chapter 5</td>
<td>Interview data is used to demonstrate that affiliation with certain types of centers leads to reports of role strain as well as to reports of increased workload due to center affiliation.</td>
</tr>
<tr>
<td>Center affiliation affects how university scientists allocate their work time, all else equal.</td>
<td>Chapter 6</td>
<td>Survey data is used to demonstrate that center affiliation alters time allocations, controlling for numerous other individual level characteristics.</td>
</tr>
<tr>
<td>Centers can be quite different from one another, even within specified centers programs such as those funded by the NSF.</td>
<td>Chapter 7</td>
<td>Center level data for the population of National Science Foundation ERCs is assessed to demonstrate how centers can differ from one another, even when they share many characteristics (such as programmatic ties).</td>
</tr>
<tr>
<td>Center level characteristics affect how center affiliated scientists allocate their work time.</td>
<td>Chapter 8</td>
<td>Center level data is used in combination with survey data to assess the impact of center characteristics on time allocations, controlling for numerous individual level characteristics.</td>
</tr>
</tbody>
</table>
University research centers and academic departments are distinct in systematic ways. If there is no variation from center to department, there can be no impact of center affiliation on behavior. In Chapter 2, I provide a brief history of university research centers to examine the broader social and political context in which academic departments were deemed (generally) inadequate for meeting certain scientific and technical expectations and needs. The challenge in this chapter is arriving at a definition of “university research center,” which, depending on the parameters, can move the starting point for any history of centers either forwards or backwards in time. In Chapter 3, I use extant study and Web based resources to identify characteristics common across centers but not departments, and vice versa. This task requires reliance, to at least a moderate extent, on generalizations about both types of academic unit.

Center affiliated university scientists perform distinct center and department roles. If center scientists do not perform distinct roles for their centers and departments, then there is no basis for using role theory and in particular the concept of role strain to predict how these scientists allocate their work time. In Chapter 4, I use survey data from the 2004 Research Value Mapping Program Survey of Academic Researchers (Barry Bozeman, PI)(see Appendix) to compare how center affiliated and “non center” university scientists allocate their work time across numerous academic tasks and responsibilities. While useful, this analysis does not distinguish clearly the center affiliated university scientist’s center role from the same scientist’s department role. All it demonstrates is that center affiliated scientists behave differently than behave scientists who do not affiliate with centers. To distinguish more convincingly the center role from the department role, also required is data on the extent to which (if at all) center affiliated
university scientists can themselves identify their center tasks and responsibilities as separate from their department tasks and responsibilities. For this I employ data from more than twenty interviews with bench scientists working in university research centers (see Appendix), all of whom at the time of the interviews were tenured or had tenure track appointments in academic departments.

*University scientists with dual obligations to centers and departments experience center induced role strain.* If center scientists do not report experiences of role strain as a result of center affiliation, required would be a new “mechanism” (Lin 1998) with which to explain why center scientists allocate their time differently than allocate non center scientists. In Chapter 5, I use the interview data introduced in Chapter 4 to demonstrate that center scientists experience role strain and, further, that reports of role strain coincide not with individual level characteristics but rather with center level attributes, as well as with reports of increased workload.

*Center affiliation affects how university scientists allocate their work time, all else equal.* After establishing (in Chapters 2 and 3) that centers and departments can differ in systematic ways, (in Chapter 4) that center scientists can fulfill distinct center and department roles, and (in Chapter 5) that center scientists can experience strain as a result of these dual roles and that this strain can result in additional work, the groundwork is laid for testing the proposition that center affiliation affects university scientists’ time allocations. In Chapter 6, I use ordinary least squares regression analysis to demonstrate that respondents to the 2004 Survey who indicate center affiliation allocate their work time differently than allocate their non center counterparts. A challenge is a data limitation per the broadness of the 2004 Survey’s definition of “university research
center” from which respondents were asked to determine whether or not any peer group with which they conduct research qualifies as a center. The definition, reviewed below, is sufficiently broad to mask substantial institutional heterogeneity across university research centers, including characteristics that may be more or less conducive to role strain.

Centers can be quite different from one another. Before testing the proposition that center level characteristics can alter center scientists’ time allocations across their academic work, in Chapter 8 I review how and to what extent they can be different. To do this, I review a preliminary attempt at a typology of centers based on RVM Program case analyses of university research centers and then analyze variation within a specific center “type,” using data collected from Web based resources for the population of currently “active” NSF Engineering Research Centers. At the end of this chapter I review variation across the centers with which 2004 Survey respondents indicate affiliation in anticipation of testing the impacts that this variation has on how center affiliated respondents allocate their academic work time.

Center level characteristics affect how center affiliated scientists allocate their work time. The crux of this study relies on the extent to which the norms and expectations of university research centers and academic departments can be established as different. Because of these differences, center scientists experience role strain and subsequently alter how they allocate their work time. However, centers do not diverge from departments uniformly. There are numerous scenarios in which the norms and expectations of centers and departments can diverge or converge and thereby affect differently the way center affiliated scientists allocate their work time. In Chapter 8, I
merge with the 2004 Survey data set the ancillary data set, introduced at the end of Chapter 7, tracking heterogeneity across the centers with which respondents indicate affiliation. I use ordinary least squares regression analysis to test the chief proposition of this study, that different centers affect scientists differently.

_It is important that center level variation affects the behaviors of university scientists._ In Chapter 9, I review and extend the major themes presented above. First, it will compartmentalize the empirical components vis-à-vis the theoretical components to reiterate the chief claims about center induced role strain and the theory and evidence used to support each claim. This section gets quite specific on the dimensions of role strain used and not used, on the data employed for each dimension, and on the strengths and weaknesses of each claim. Next, briefly reviewed are the implications of these claims for theory. As I mentioned at the outset of this study, as with most other applications (Biddle 1979, Pandey & Kumar 1997) use of role theory and the concept of role strain was first and foremost to frame a practical problem of science policy, not to further theory. No less this study poses minor implications for application of the concept of role strain to modern day university scientists as well as for human capital theories of time allocation. Last are the policy implications. In this section, hypothetical policy scenarios are presented as starting points to discuss how specified dimensions of center induced role strain may be alleviated. These scenarios are by design “extreme” and intended to demonstrate the difficulty of policy action regarding such alleviation. The final scenario considered is that center induced role strain cannot be alleviated but rather should be managed to ensure the job satisfaction and productivity of university scientists.
2. A RECENT HISTORY OF UNIVERSITY RESEARCH CENTERS

Most definitions of university research centers are sufficiently general to encompass an enormous swath of university based, extra departmental research activities. Some definitions are so broad as to date the history of centers back to the nineteenth century with university based observatories and even museums (e.g., Geiger 1990). Other definitions are much more specific in emphasizing the features of modern centers that are both multipurpose and multidiscipline, thereby dating the historical starting point for centers much later (e.g., Bozeman & Boardman 2003). Still others emphasize multidisciplinarity and interdisciplinarity (e.g., Ikenberry & Friedman 1972) or dependence on funding from external stakeholders (e.g., Zajkowski 2003), but (perhaps wisely) make no attempt at pinpointing when centers were first established.

In this chapter, I review a selection of previous definitions and, fewer, previous histories of university research centers. I place especial emphasis (in the final section) on the emergence of National Science Foundation Engineering Research Centers (ERCs), as this particular centers program has spawned numerous imitators in the United States and elsewhere and constitutes perhaps the most significant institutional change in U.S. science and technology policy to occur over the past three decades (Bozeman & Boardman 2004). Accordingly, ERCs, with their interdisciplinary and cross sector collaborative approach to problem focused research and also to student development, seem to be what many scholars and policy makers prototypically have in mind when discussing (and establishing new) university research centers.
Defining university research centers

There are numerous attempts to formally define university research centers, most of which use the academic department as a baseline for comparison (e.g., Becker & Gordon 1966, Ikenberry & Friedman 1972, Geiger 1990, Bozeman & Boardman 2003). Many of these definitions become vague once the task shifts from differentiating centers from departments to that of distinguishing centers from other extra departmental research units, such as institutes and laboratories. Most work on centers, however, use these and like terms interchangeably (e.g., Stahler & Tash 1994). Others use the blanket term “organized research unit” (e.g., Friedman & Friedman 1982).

Nomenclature notwithstanding, attempts to define university research centers usually resort to listing attributes common across centers. Stahler & Tash (1994) list only one common attribute, the conduct of research, in their self described “simplistic” definition (p. 541) and focus the remainder of their analysis on variation across centers in terms of external funding, number of faculty, separation from academic departments, integration with the university, interdisciplinarity, emphasis on applied research, and so on. However, a closer inspection reveals much more than the authors suggest about centers’ shared characteristics.

Centers, generally but of course to varying degrees, are funded by external stakeholders, they are (typically) organizationally distinct from academic departments, they are affiliated with universities, they (increasingly) retain as members faculty from more than one discipline or field, they engage in applied or problem focused research. Other more formal attempts at a definition explicitly include many of these characteristics:
“A ‘centre’ may be seen as a strategic device intended by its institutional hierarchy to emphasise research strength, aimed at encouraging external funding bodies to support the research...” (Zajkowski 2003, p. 206).

“We define [a center] as a formal organizational entity within a university that exists chiefly to serve a research mission, is set apart from the departmental organization, and includes researchers from more than one department” (Bozeman & Boardman 2003, p. 17).

“[A center] is a semi-autonomous research entity within a university that operates independently of academic departments... [they] typically involve multidisciplinary teams of researchers, a portfolio of research projects... and sometimes have access to some significant piece of equipment and/or facilities (Gray et al. 2001, p. 248).

“What have here been typified as ‘centers’ were often intended to facilitate interdisciplinary investigations...their participants largely remained rooted in established departments; the research undertaken... was supported by outside agencies for nonacademic reasons” (Geiger 1990, p. 10).

How (if at all) one defines “university research center” can affect how far back in time one’s chronicle of center history goes. If in one’s definition one emphasizes simply that centers conduct research outside academic departments but no less on a university campus, one’s chronicle of university research centers, at least for the U.S., may date back to the Harvard Observatory, established in 1844, if not before (Geiger 1990). Add the criterion of center research being “applied” or at least “directed” (Stokes 1997) and,
further, the criterion of center research requiring expertise of scientists from more than
one field or discipline, the starting point moves forward in time somewhat, perhaps to the
Land Grant universities’ Agricultural Experiment Stations (prompted by the 1887 Hatch
Act). Add the attribute of research and technology development conducted “in the
national interest” (e.g., to aid national competitiveness) and one’s chronicle becomes
significantly shorter, starting in the 1970s or quite possibly not until the mid 1980s with
the advent of the ERC program (Bozeman & Boardman 2003, p. 9).

**Chronicling the history of university research centers**

It is not my intention to provide a comprehensive history of a broad swath of
university research centers. As the above definitions help to demonstrate, such a
chronicle is a task so large as to warrant a separate (and perhaps a much larger) study
altogether. Moreover, the inevitability of variation in the scholarly application of any
hypothetically agreed upon parameters for defining centers (e.g., determining whether
center research is “problem focused” or “directed” or neither) renders the task all the
more impractical. My intention thus far has been to demonstrate that there can be equally
valid, albeit quite different, definitions of “university research center,” a point upon
which I elaborate in Chapter 7 (on institutional variation across centers and also across
centers within specific centers programs). My intention going forward (in this chapter) is
not to attempt a new definition of centers but rather to pick a starting point in time from
which to extrapolate an historical account of university research centers.

I employ a programmatic (rather than abstract) boundary to help select my
starting point: the ERC program, which began in 1984 under the auspice of the National
Science Foundation. I do not use ERCs as a baseline from which to demarcate between
what constitutes a center and what does not. A majority of the centers I analyze in the empirical components of this study (below) are not part of any formal centers program, much less part of a program as competitive and exclusive as the ERC program.\textsuperscript{15} Rather, my aim is to develop well the history of a modest (albeit a quite significant) period in centers history (Boardman & Bozeman 2004). Extant histories that take an exclusively abstract tack (based on definitions similar to those discussed above) oftentimes end up with substantial though unintentional omissions and, moreover, they can end up comparing apples to oranges, discussing, for instance, university based museums and weapons research laboratories in the same breath (e.g., Geiger 1990).

Despite their programmatic origins, ERCs as a unit of historical analysis are not entirely material or “non abstract.” In previous study (Bozeman & Boardman 2003, Bozeman & Boardman 2004), ERCs are demonstrated to be the advent of those university research centers that are both “multipurpose” and “multidiscipline,” depending, of course, on the definition one chooses to employ. These attributes, together with ERCs’ “hands on” approach to educating undergraduate and graduate students, have spawned numerous imitators, in the form of both large centers and small, both in the U.S. and abroad (Bozeman & Boardman 2004). In these ways, ERCs constitute perhaps the prototypical university research center. ERCs are not prototypes in the institutional isomorphic (DiMaggio & Powell 1983) sense whereby most other centers have become (or are becoming) quite similar in terms of organizational structure, but rather they are prototypical in the sense that ERCs’ attributes of multidisciplinary and problem focused research as well as multidisciplinary and problem focused (undergraduate and graduate) education seem to be what many scholars and policy makers have in mind when

\textsuperscript{15} Currently there are seventeen active ERCs.
discussing and establishing new university research centers (Bozeman & Boardman 2004).

**The origins, proliferation, and progeny of ERCs**

Before reviewing the origins of the ERCs, it is important to address how and why they (and like institutions) emerged. There are many reasons for university research centers, including the increased cost of equipment-intensive science, the importance of interdisciplinary research, and the desire to change science and engineering education by making it more “hands on” and, accordingly, more involved with applied science and technology development. But among the many factors contributing to the changed university research environment, none is more important than the effort to harness university research to applied and commercial objectives and to national and regional economic development (Geisler 1995).

While many government agencies have set up university research centers, it is no less the case that a significant portion of centers history is interwoven with that of the NSF. The ERCs were established by NSF in the midst of the perceived U.S. “competitiveness crisis” of the early 1980s on recommendation from a National Academy of Science panel. Though ERCs were not the first U.S. university research centers, nor even the first NSF funded centers, they served notice of a sea change in university research funding and institutional designs, constituting perhaps the genesis of what has been called the “multipurpose, multidiscipline, university research center” (Bozeman and Boardman 2003). 16 Whereas the NSF had prior experience with

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16 Prior to the establishment of ERCs, there were certainly multidisciplinary, multipurpose and even multi-institutional centers, but none approached the scope or scale of the ERCs. This is not to say that size is an important criterion for centers, but rather that size is important as a second order effect. ERCs had
centralized, university-based research centers with its materials science research centers and its industry/university cooperative research centers, the ERCs were different in goals, design and, not insignificantly, the magnitude of funding.

**The origins of ERCs**

In his contribution to the final report for the 1986 CETS\textsuperscript{17} symposium\textsuperscript{18} on future expectations for the then nascent NSF Engineering Research Centers (ERC) program, George A. Keyworth II, Science Advisor to the President and Director of the Office of Science and Technology Policy (OSTP), described how the idea for the ERCs first came to be. It happened during a 1983 presentation made by the Committee on Science, Engineering, and Public Policy (COSEPUP)\textsuperscript{19} to the OSTP on the subject of computers in design and manufacturing. Keyworth (1986) explains:

“The presentation brought home to all of us how radically the role of the engineer will change in light of the tremendous information-processing capabilities that are emerging... After the presentation we were convinced that we should be doing more to help integrate engineering practice and training... and that our future industrial successes were going to depend on the availability of different kinds of engineers than those who had been successful in the past.”

\textsuperscript{17} National Research Council’s Commission on Engineering and Technical Systems (CETS).

\textsuperscript{18} The symposium titled “The Engineering Research Centers: Factors Affecting Their Thrusts” was held on April 29-30, 1985 under the auspices of CETS.

\textsuperscript{19} COSEPUP was a joint committee of the National Academies of Science and Engineering and the Institute of Medicine. The presentation was on then new information processing capabilities, such as that enabled by the 1-megabit RAM chip.
Following the presentation, Keyworth and colleagues, including George Low, president of Rensselaer Polytechnic Institute, turned to the National Academy of Engineering (NAE) to assemble a panel for developing new strategies with which NSF and the university system could transform the American engineer, who was up to that point believed to be focused on narrow, discipline-based topics, into a cross-disciplinary scientist and practitioner possessing synthesis-oriented skills such as systems design, optimization, and integration (Suh 1986).

In February 1984, the NAE panel, comprised of engineering leaders from universities and industry, responded with a report, *Guidelines for Engineering Research Centers*. The report expressed the goal of a more hands-on approach to engineering research and education in terms of the broader U.S. mission of international competitiveness (Mayfield 1987):

“The goal of the centers is to improve engineering research so that U.S. engineers will be better prepared to assist U.S. industry in becoming more competitive in world markets. Thus, engineering research and education must be judged by their success in achieving this linkage.”

The tone of the report was appropriate to the times. Throughout the 1970s and into the eighties, American industry was being outperformed by newly industrialized nations building niche technology infrastructures which, combined, proved formidably competitive to the U.S. in the world industrial market. Korean steel, Japanese automobiles, Taiwanese electronics, and Indonesian aircraft set off a perceived “competitiveness crisis” both in the U.S. and in Europe, which is often credited as the catalyst for the ERC program. Consequently, the budget proposal to Congress for fiscal
year (FY) 1985 included $10 million for ERCs, setting the stage for a new Engineering Directorate at NSF. After the first round of proposal solicitation and review in 1984, NSF funded six centers for 1985-86. The goal then was for NSF to eventually fund 19 centers in addition to the original six.

**ERCs’ common goals, divergent research foci**

In the 1984 *Guidelines*... report, the NAE panel identifies two main goals for the ERC program. The first goal was to improve engineering research and education so that engineers training in American universities could more readily contribute to engineering practice once they graduate. The second goal was, by training engineers in more industry-relevant ways, to assist U.S. industry in becoming more competitive in world industrial markets.

The NAE panel advised that all ERCs should have three characteristics in common. First, ERCs should foster regular interaction among university engineers and scientists, including students, with their counterparts in industry to ensure that the research conducted in ERCs stays relevant to the needs of the engineering practitioner and, moreover, to facilitate knowledge flow and technology transfer between the academic and industrial sectors. Second, ERCs should promote interdisciplinarity in its research to bring together the knowledge, methodologies, and tools required for the engineering practitioner to solve problems important to an industrial sector or sectors. Third, all ERCs must have an educational component designed to attune future U.S. engineers to the needs of industry, specifically in terms of hands-on engineering research and education (Parker 1997).
Despite these common goals and characteristics, the scope of the engineering research topics upon which ERCs focus is broadly diverse. The first ERCs, which emerged from the first round of proposal solicitation and review in 1984 and were established in 1985-86, focused on the areas of systems research, intelligent manufacturing systems, robotic systems in microelectronics, telecommunications, and biotechnological processes (NAS 1986). Since that time, the research emphases of ERCs has expanded to include earthquake engineering research, environmentally-benign semiconductor manufacturing, and subsurface sensing and imaging technology, to name a few.

Today, NSF classifies all ERCs under one of four program meta-thrust areas for engineering research, which do not differ greatly from the research foci of the original six ERCs founded in 1985-86. These meta-thrusts include bioengineering manufacturing and processing (5 centers), earthquake engineering (3), microelectronic systems and information technology (6), and manufacturing and processing (3).

**ERC program growth: number of centers**

At the outset of the ERC program, there were six ERCs receiving NSF funds. By 1990, NSF had established 23 ERCs in addition to the original six, though many of these failed to qualify for renewed funding prior to the completion of the 11 year award cycle (Feller *et al.* 2002). By 1994, eighteen ERCs were operating. In 1997, another ERC was added, increasing the count to 19 centers. As of October 2003, there were 22 centers receiving funds through the ERC program. For a list of current ERCs and their thrust affiliation, see Table 4 below. As of April 2006, 17 ERCs are “active” (i.e., still receiving NSF support) and 16 are self-sustaining after the conclusion of NSF support.
Table 4. Active ERCs (as of April 2006)

<table>
<thead>
<tr>
<th>Thrust</th>
<th>Center</th>
<th>Lead institution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bioengineering manufacturing and processing</strong></td>
<td>ERC for the Engineering of Living Tissues</td>
<td>Georgia Institute of Technology, Atlanta, GA</td>
</tr>
<tr>
<td></td>
<td>Center for Computer-Integrated Surgical Systems and Technology</td>
<td>Johns Hopkins University, Baltimore, MD</td>
</tr>
<tr>
<td></td>
<td>ERC for Biomimetic MicroElectronic Systems</td>
<td>UCLA Keck School of Medicine, Los Angeles, CA</td>
</tr>
<tr>
<td></td>
<td>VaNTH ERC for Bioengineering Educational Technologies</td>
<td>Vanderbilt University, Nashville, TN</td>
</tr>
<tr>
<td></td>
<td>Engineered Biomaterials Engineering Research Center</td>
<td>University of Washington, Seattle, WA</td>
</tr>
<tr>
<td><strong>Earthquake engineering</strong></td>
<td>Pacific Earthquake Engineering Research Center</td>
<td>University of California at Berkeley, CA</td>
</tr>
<tr>
<td></td>
<td>Mid-America Earthquake Center</td>
<td>University of Illinois at Urbana-Champaign, IL</td>
</tr>
<tr>
<td></td>
<td>Multidisciplinary Center for Earthquake Engineering Research</td>
<td>University at Buffalo at Buffalo, NY</td>
</tr>
<tr>
<td><strong>Microelectronic systems and information technology</strong></td>
<td>ERC for Extreme Ultraviolet Science &amp; Technology</td>
<td>Colorado State University, Fort Collins, CO</td>
</tr>
<tr>
<td></td>
<td>Center for Power Electronic Systems</td>
<td>Virginia Tech, Blacksburg, VA</td>
</tr>
<tr>
<td></td>
<td>Integrated Media Systems Center</td>
<td>University of Southern California</td>
</tr>
<tr>
<td></td>
<td>Center for Subsurface Sensing and Imaging Systems</td>
<td>Northeastern University</td>
</tr>
<tr>
<td></td>
<td>ERC for Collaborative Adaptive Sensing of the Atmosphere</td>
<td>University of Massachusetts, Amherst, MA</td>
</tr>
<tr>
<td></td>
<td>Center for Wireless Integrated MicroSystems</td>
<td>University of Michigan at Ann Arbor</td>
</tr>
<tr>
<td><strong>Manufacturing and processing</strong></td>
<td>Center for Advanced Engineering of Fibers and Films</td>
<td>Clemson University, Clemson, SC</td>
</tr>
<tr>
<td></td>
<td>Center for Environmentally Beneficial Catalysis</td>
<td>University of Kansas, Lawrence, KS</td>
</tr>
<tr>
<td></td>
<td>Center for Reconfigurable Machining Systems</td>
<td>University of Michigan, Ann Arbor, MI</td>
</tr>
</tbody>
</table>

Source: http://www.erc-assoc.org/centers.htm
<table>
<thead>
<tr>
<th>Thrust</th>
<th>Center</th>
<th>Lead institution (dates active)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bioengineering manufacturing and processing</strong></td>
<td>ERC for Emerging Cardiovascular Technologies</td>
<td>Duke University (established in 1987, graduated in 1998)</td>
</tr>
<tr>
<td></td>
<td>Center for Biofilm Engineering</td>
<td>Montana State University (established in 1990, graduated in 2001)</td>
</tr>
<tr>
<td></td>
<td>Institute for Systems Research</td>
<td>University of Maryland/Harvard University (established in 1985, graduated in 1996)</td>
</tr>
<tr>
<td></td>
<td>Center for Interfacial Engineering</td>
<td>University of Minnesota (established in 1988, graduated in 1999)</td>
</tr>
<tr>
<td></td>
<td>ERC for Net Shape Manufacturing</td>
<td>Ohio State University (established in 1986, graduated in 1997)</td>
</tr>
<tr>
<td></td>
<td>Center for Intelligent Manufactured Systems, reestablished as the ERC for Collaborative Manufacturing</td>
<td>Purdue University (established in 1985, reestablished in 1994, and graduated in 1999)</td>
</tr>
<tr>
<td><strong>Microelectronic systems and information technology</strong></td>
<td>Data Storage Systems Center</td>
<td>Carnegie Mellon University, Pittsburgh, PA (established in 1990, graduated in 2001)</td>
</tr>
<tr>
<td></td>
<td>Optoelectronic Computing Systems Center</td>
<td>University of Colorado/Colorado State University (established in 1987, graduated in 1998)</td>
</tr>
<tr>
<td></td>
<td>Center for Telecommunications Research</td>
<td>Columbia University (established in 1985, graduated in 1996)</td>
</tr>
<tr>
<td></td>
<td>Center for Compound Semiconductor Microelectronics</td>
<td>University of Illinois at Urbana-Champaign (established in 1986, graduated in 1997)</td>
</tr>
<tr>
<td></td>
<td>Center for Computational Field Simulation</td>
<td>Mississippi State University, Mississippi State, MS (established in 1990, graduated in 2001)</td>
</tr>
<tr>
<td></td>
<td>Center for Advanced Electronic Materials Processing</td>
<td>North Carolina State University (established in 1988, graduated in 1999)</td>
</tr>
<tr>
<td><strong>Energy, environment and infrastructure</strong></td>
<td>Advanced Combustion Engineering Research Center</td>
<td>Brigham Young University (established in 1986, graduated in 1997)</td>
</tr>
<tr>
<td></td>
<td>Center for Advanced Technology for Large Structural Systems</td>
<td>Lehigh University (established in 1986, graduated in 1997)</td>
</tr>
<tr>
<td></td>
<td>Offshore Technology Research Center</td>
<td>Texas A&amp;M University (established in 1988, graduated in 1999)</td>
</tr>
</tbody>
</table>

*Source: [http://www.erc-assoc.org/factsheets/overview.html](http://www.erc-assoc.org/factsheets/overview.html)*
Since the ERC program’s inception in 1984, NSF has awarded 56 grants to establish ERCs. Figure 1 tracks the distribution of these rewards by year.

Figure 1. ERC awards by year, 1984-2004

An important observation to take away from Figure 1 is the discrepancy between number of awards granted and the number of centers currently receiving NSF funds. While some have graduated and are now self-sufficient, others have failed to successfully navigate the renewal process.

By November 2003, 41 ERCs and 3 Earthquake ERCs had been funded by NSF. This constitutes an historical renewal (or survival) rate for ERCs of .79.

**ERC program growth: magnitude of funding**

Currently NSF funds approximately 30 percent of ERC total annual budgets, with industry, other federal agencies, universities, and the states providing the remainder (Lewis 2004). The ERC program constitutes a substantial proportion of annual NSF expenditure on engineering research and related activities. In FY2003, ERCs and their spin-offs received higher levels of funding than any other NSF engineering research
endeavor, save SBIRs (small business innovation research). Of the $132.7 million that NSF spent on engineering education and centers (EEC) in FY 2003, NSF allocated nearly half, $65.72 million, to the ERC program. If this calculation is also to include NSF expenditure on Earthquake Engineering Research Centers, Nanoscale Science and Engineering Centers, and Science and Technology Centers, the amount increases by $19.89 million to nearly $86 million, or 65 percent of NSF expenditure on EEC and approximately one sixth of overall NSF engineering expenditure.\(^{20}\)

Figure 2. NSF spending 1994-2005


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\(^{20}\) Total expenditure on centers divided by total engineering expenditures equals 85.71/541.7. See Tables 2.4 and 2.5
Estimates for FY 2005 demonstrate a modest decrease in NSF funding for the ERC program over the next year. To support a steady state of 19 ERCs, NSF has requested $63.49 million, which is down more than $2 million from FY 2004 and down nearly $2.25 million from 2003.

**ERC program progeny**

The ERC program has served as a model for many other university research centers in the U.S. and elsewhere. Perhaps the most conspicuous progeny of the ERCs is the NSF’s own Science and Technology Centers (STC) program. In a 1987 letter to NAS President Frank Press, NSF Director Erich Bloch indicates that the STC program was a direct spin off of the ERC program (Metzger 1987):

> “Just as the National Academy of Engineering played a pivotal role in shaping the approach NSF used to establish and administer the Engineering Research Centers, a similar contribution can be made by the National Academy of Sciences with regard to [the STC program] initiative.”
The ERC concept has been extremely influential in other nations. For example, just a few years after the ERC implementation in the U.S., the United Kingdom implemented a program based explicitly on the ERC model. The Science Foundation of Ireland (SFI) not only set up its program Centers for Science, Engineering, and Technology but recruited former director of the NSF’s Science and Mathematics Division, William Harris, to serve as the SFI Director General.

One of many examples, a quite recent one, of the influence of the ERC as a model is a pending proposal, outlined in an options paper prepared by the Space Science Working Group, a group of space scientists and university government relations officers, for “university-based research centers modeled after the National Science Foundation’s Engineering Research Centers” (Association of American Universities and the National Association of State Universities and Land-Grant Colleges, 2003, p. 1). This whitepaper on “NASA-University Workforce Development” seeks to expand NASA’s ability to replace its rapidly retiring scientific and technical workforce with highly qualified next-generation scientists and engineers by having NASA “sponsor university centers, similar in structure to the Engineering Research Centers…” and thereby establishing a “structure envisioned for NASA-supported university centers… that would give both graduate and undergraduate students and opportunity to get hands-on experience in NASA-oriented skills” (p. 1-2).

**ERCs and the larger population of university research centers**

This brief history demonstrates that ERCs share numerous characteristics with other university research centers. Like many other centers, ERCs are designed to foster interaction among university faculty from different departments and also between faculty
and students. They are designed to bring together the knowledge, methodologies, and tools required to conduct multidisciplinary and applied research.

ERCs, however, are also exceptional. Unlike most other university research centers, ERCs regularly interface with industry to ensure that the research conducted in ERCs stays relevant to the needs of the engineering practitioner and, moreover, to facilitate knowledge flow and technology transfer between the academic and industrial sectors. ERCs conduct problem focused research to meet the needs of industry. They are also part of a large (NSF) centers program with reporting and renewal requirements that far exceed the administrative requirements (if any) of centers with different or no programmatic origins. Last, ERCs are funded on a level that distinguish them not only from non programmatic university research centers, but also from other centers programs which provides significantly less funds to their member centers (Bozeman & Boardman 2004).

These differences I address later in Chapters 7 and 8, which focus on institutional variation across centers. The point here has been to demonstrate how centers constitute a departure from the traditional way in which universities pursue the creation of new knowledge and, moreover, a departure from how universities have traditionally related to the needs and expectations of stakeholders outside academia, including industry and even society. The next chapter focuses more specifically on how centers differ from academic departments.
3. DISTINGUISHING CENTERS FROM DEPARTMENTS

To assert that university research centers have an impact on center affiliated university scientists’ behaviors is to assert that centers are somehow different than departments. Indeed, this assertion is the most fundamental I make throughout the entirety of this study. Though centers and departments are similar in that they claim university faculty as members and that they encourage these members to conduct research and attendant tasks and responsibilities, this is where the similarities (usually) end. In fact, the “similarity” of research is oftentimes a key point of distinction in comparisons between centers and departments (e.g., Stahler & Tash 1994).

Distinguishing centers from departments is a relatively easy task, and one with precedent (e.g., Ikenberry & Friedman 1972). However, doing so with conceptual clarity and accuracy is another matter altogether. Whereas some scholars juxtapose centers and departments as coexisting in a state of perpetual (though not assured) conflict over the scarce resources of faculty time, internal funding support, space and infrastructure, and the like (e.g., Stahler & Tash 1994), others situate departments and centers close by on the continuum of “organized research units,” with as many common as disparate attributes (e.g., Geiger 1990).

No doubt this analytic variation is attributable in large part to difficulty surrounding the definition of “university research center” (see Chapter 2). When is a group of researchers a “center?” How, if at all, are centers different than “institutes” or “laboratories?” Variation in the analysis of center attributes, moreover, may also be a function of the samples studied. For instance, an assessment of Engineering Research
Centers may yield very different generalizations about management structure than will an assessment of centers without substantial infrastructure, with few or no industry partners much less an industrial advisory board, and operating on relatively small budgets. Depending on the definition and data one employs, one can find as much variation among centers as across centers and departments.

I address variation among university research centers in Chapters 7 and 8. For this chapter, the task is distinguishing the organizations that are centers from those that are departments, the foundation upon which is based my assertion that center affiliated university scientists play separate center and department roles. If centers and departments do not differ in significant ways, nor can their norms and expectations and “social systems” (Weick & Roberts 1993) differ; nor, in turn, can differ the workaday behaviors that centers and departments expect of their faculty.

I use a mix of extant characterizations of centers and departments in conjunction with evidence procured from current centers’ Web sites as well as from field studies and interviews with center directors and scientists from an earlier project on the management of university research centers (i.e., Bozeman & Boardman 2003) to make the case that centers and departments differ in important and systematic ways. Based on these characterizations, I delineate centers and departments across a variety of variables including practices, missions, material arrangements, and (internal and external) interactions (Schatzki 2005). This task requires reliance, to at least a moderate extent, on generalizations about both types of academic unit. I identify (and justify) when doing so along the way.
Characteristics common across departments

Though there is study of variation across academic departments (e.g., Schatzki 2005, Pfeffer & Langton 1988), by and large they share numerous characteristics. Such commonality is suggested insofar as a large proportion of sociological study of departments emphasizes strategies for changing the ways departments organize and operate (e.g., Walvoord et al. 2000, Romey 1975). Many of these studies characterize departments as bulwarks against change, as “silos or dinosaurs or barriers” (Walvoord et al. 2000, p. 2), as “the most substantial barrier against externally imposed innovations” (Becher & Kogan 1992, p. 136).

Focusing on those departmental features that “require change” (e.g., disciplinary isolation, see McHenry 1977 for an early treatment), while useful for pointing up major differences between centers and departments and indeed useful for illustrating some of the policy rationale for implementing centers in the first place, no less does not provide a comprehensive idea of the activities, relationships, norms, personnel, outputs, material infrastructure, and so on that constitute academic departments. While I make certain to address those features of departments that bear the brunt of analyses conducted by scholars and practitioners critical of departments, I address as well the many uncontroversial features common across academic departments, such as shared office space and residence on a university campus. A complete idea of the academic department is requisite for an accurate comparison of centers to departments. It is as important to assess characteristics that centers and departments share as it is to assess those they do not.
Few studies actually define (the boundaries of or practices characteristic of) academic departments, a prerequisite to the current task of contrasting departments from university research centers. Previous attempts at a “tidy” definition have proved elusive due to the diverse functions of academic departments (Andersen 1977, p. 2). One recent study (Schatzki 2005) stands out for its relatively abstract definition of academic departments:

“An academic department is a bundle of practices and material arrangements…Many of these arrangements are contiguous or continuous, some are connected by communication lines, and most are connected to further material arrangements that are not part of the department bundle” (p. 474).

Other definitions apply more exclusively to academic departments (rather than to organizations generally) and, accordingly, are more aligned with what we typically have in mind when discussing departments:

“Academic departments are discipline-based units charged with teaching, research, and service missions” (Bozeman & Boardman 2003, p. 18).

“…the academic department is the basic administrative unit of the college, housing a community of scholars that is relatively autonomous and responsible for instruction and research within a specialized field of knowledge” (Andersen 1977).

These definitions provide useful categories for characterizing departmental (and, in the next section of this chapter, center) attributes. “Practices,” “material arrangements,” and “missions” help to organize this review of those features common
across academic departments. Also important are characteristics such as autonomy and specialization. Further, I include as a category “interactive processes” (Schatzki 2005) to discern management and communication mechanisms common across academic departments.

Though I treat these four categories separately, each intermingles with the others. For instance, there is little meaningful difference between the departmental “practice” and the departmental “mission” of research, save the ideal that the latter in some way influences the former. Even the within category differences can be conceptually fuzzy. Consider the overlap between many departments’ teaching and research missions (Bozeman & Boardman 2003). However artificial, the categories remain useful insofar as they are amenable to systematic differentiation of centers from departments.

Departmental practices

Though the current unit of analysis is the academic department, when thinking of departmental practices one cannot help but think of the individual level behaviors that characterize the roles of university scientists. By way of their faculty, departments teach, evaluate, and advise students; they conduct and disseminate research, manage research projects and funds, and work to bring in additional funds for future research; they perform administrative tasks; they perform university and community services; and so on. Beyond discussion of university scientists’ individual behaviors, departments conduct practices that cannot be attributed to the actions of a single (or small group of) faculty member(s). For instance, departments form committees to admit and (less often) to sanction or expel students, to hire and (less often) to sanction or fire staff and faculty, to award and (less often) to deny tenure or promotion, to procure and manage budgets, to
promote faculty development, to procure space and equipment for laboratories, to plan and evaluate curricula, and to negotiate with external stakeholders from within and outside the university. Biddle (1979) notes:

“Just when we presume to have pinned down the functional significance of a given role with a list of impressive sounding outcomes, a more insightful observer comes along to show us other outcomes we have not considered” (Biddle 1997, p. 71).

However, the point here is not to chronicle every departmental practice. The chief difference between the practices that characterize academic departments and those that characterize university research centers is not so much one of content or substance (though certainly there are practices that characterize departments but not centers, and vice versa), but rather the difference is one of priority. For instance, teaching and student advising, while a major practice of safely all academic departments, may or may not be a priority in a university research center (Ikenberry & Friedman 1972, Bozeman & Boardman 2003). Even in centers that emphasize education, student related practices may be less valued than the conduct of research or than interaction between center faculty and industry partners.

Instead, the point is to conceptualize departmental practices as “non-individualist” phenomena (Schatzki 2005) that, when taken together and facilitated by managerial and physical infrastructure, comprise the “social system” (Weick & Roberts 1993) that is the academic department. Certainly university scientists perform the actions that constitute various departmental practices, but departmental practices are more than the compiled behaviors of individual faculty members. Practices constitute defining features for
academic departments, features that persist no matter who is hired on as faculty but no
less cannot exist apart from these persons. Accordingly, departmental practices represent
not only the behaviors of individual (and groups of) faculty members but also the
collective norms and values and therefore the expectations that encourage these
behaviors. I return to this theme (in Chapters 5 through 8) when using role theory to
formulate the hypotheses for the empirical components of this study assessing the impact
of institutional variation in university research centers on the behaviors of university
scientists.

Departmental missions

Just as it is difficult to conceptualize departmental practices without discussing
the behaviors of individual university scientists, it is difficult to conceptualize
departmental missions without discussing departmental practices. This is perhaps because
most academic departments do not formally state their missions (Hatfield 2000) and one
must observe departmental practices to get an idea of “mission.” To grasp departmental
missions, I rely on what I can glean from the extant literature concerned with academic
departments.

Academic departments are generally charged (by their home universities and, if
their home university is publicly funded, by tax payers) with teaching, research, and
service missions (Bozeman & Boardman 2003). Though there is criticism that these
missions do not reflect “realistically the full range of academic and civic mandates”
(Boyer 1990, p. 16) to which departments are (or should be) beholden, this criticism does
not undermine the validity of the conventional tripartite delineation. Rather, it simply
calls for increased specificity in departmental missions. For instance, Boyer (1990)
identifies four separate research practices that, he argues, ought to be considered as separate components of departments’ research missions, including fundamental research, interdisciplinary research, applied research, and pedagogical research. Difficulty in discerning between these types of research (Stokes 1997) notwithstanding, the central idea is that a more precise statement of departments’ variegated practices (and therefore missions) will necessitate or at least justify a broadening of the academic reward template to emphasize numerous other activities in addition to the traditional emphasis on peer reviewed publishing activity.

Despite evidence of departments becoming more applied and interdisciplinary (Morris 2002), it would be going too far (at least at this point in time) to designate, for instance, “application” and “interdisciplinarity” as research missions common across academic departments. There remains evidence of departmental bias towards single discipline and basic research in tenure and promotion decisions (e.g., Siegel et al. 2003). Further, many recent studies advocating change in academic departments aim their sites on disciplinary bias or “specialization” (e.g., Walvoord et al. 2000), which suggests that interdisciplinarity does not constitute the norm for academic departments. Disciplinary specialization, while perhaps no longer so narrowly focused to cause the “maiming and mutilation of the mind that comes from over-absorption in one subject” (Veysey 1965, p. 200), no less is the primary distinction to make from one academic department to the next and, as I demonstrate in the last section of this chapter, to make between departments and university research centers.

Most academic departments have a difficult time generating consensus around any conceptualization of departmental mission other than the traditionally generalist
teaching-research-service trichotomy (Hatfield 2000). So I use this triad when comparing departmental missions to those of university research centers. Further, DiLorenzo and Heppner (1994) make a strong case for a fourth departmental mission of faculty development, though it is a relatively recent phenomenon (at least in explicit form) and, accordingly, may be less common across departments.

**Departmental material arrangements**

Delineating the material arrangements of academic departments is a matter of examining the infrastructure and technological assets common to departments across disciplines and universities. This is a relatively basic task, but one that has no precedent in the empirical literature (that I am aware of) and one for which I have no empirical basis beyond my own experiences in numerous U.S. universities. However, I do not think many would disagree with the list of material assets compiled by Schatzki (2005), which includes “layouts and material connections” between offices, meeting rooms, hallways, front offices, common areas, and (even) faculty members’ homes (p. 474).

To this list I add classrooms, laboratories, and even lavatories. Moreover, since Schatzki does not limit his list of departmental material assets to those contained within the department building (e.g., faculty members’ homes), I include campus infrastructure such as parks or greenspace, restaurants, libraries, and coffee shops. Also missing from the list are the specifics of “material connections,” which no doubt include computers, telephones, and scientific instrumentation. Many of these material arrangements are connected to each other, either by physical proximity or by (wired or wireless or paper) communication lines, and most are connected to further material arrangements that are not part of the academic department, including university research centers.
Departmental interactive processes

Decades of research on organizations and organizational behavior demonstrate that the way an organization is structured can affect the way its members interact. Structure, as the term applies to organizations, may vary in complexity, formalness, and centralization (Hall 2002). Complexity refers to how deep (vertical), how wide (horizontal), and how dispersed (geographically) is an organization. Formalization refers to the rules and procedures (or lack thereof) governing organizational members’ interactions. Centralization refers to the nature of the decision making process in an organization, whether the process is “top down,” “bottom up,” or somewhere in between. Taken together, these structural characteristics have outcomes for the way an organization operates and for that organization’s broader workaday culture. For instance, high levels of centralization, while affording organizations increased coordination, can limit flexibility (Hall 2002) and creativity (Kamoche & Pina e Cuhna 2002), both important to academic departments’ (as well as centers’) research missions.

While the organizational structures of academic departments undoubtedly vary, for instance according to size (e.g., Daft & Bradshaw 1980), one can no less envision common levels of complexity, formalization, and centralization across departments. However, there is little (systematic) study of the organizational structure of academic departments (that I am aware of) from which to extract an idea of the “typical” departmental organizational structure. I do not pursue such a goal here, for no small reason that the task is quite demanding given the quantity of departments in U.S. universities, not to mention accounting for variation across time, university “type” (i.e., Carnegie classification), and discipline. Further, a comprehensive review of the
organizational structure of academic departments is beyond the scope of this study. A few illustrative cases using departments’ organization charts are sufficient to help distinguish between the way academic departments and centers organize, both internally and within the larger structure of the university and in relation to external stakeholders.

Below is a reproduction of the organization charts of a university chemistry department in a doctoral granting university (Carnegie 2005). I include this chart to illustrate that the way in which department faculty typically relate (organizationally, not socially or psychologically or intellectually) to each other, to support staff, and to the department head or chair as relatively “flat” or non hierarchical.

Figure 4. The organization chart for the chemistry department of a Carnegie classified doctoral granting university

Source: http://www.chem.uga.edu/DoC/DepOrg.html
In this chemistry department’s case, organizational structure seems not so “complex” (Hall 2002). Vertically (or hierarchically), university faculty members have direct access to the department head (or chair) as well as to support staff. Additionally, there appears to be a faculty supervisory tier (A-C) mitigating relations between the department head and other, non-supervisory faculty members (who are not included in the chart). However, this tier may not exist in smaller departments. That this department contains 67 faculty members, 20 staff, and only four tiers of hierarchy (i.e., department head, faculty supervisors, faculty, and support staff) suggests a relatively horizontal structure wherein there is plausibly much lateral communication among colleagues and frequent interaction across levels of the hierarchy.

Perhaps more helpful in the task of distinguishing academic departments from university research centers is contrasting how academic departments fit into the larger organizational structure comprised of the university and external stakeholders (such as funding institutions).
This figure provides a simple model of the organizational structure in which academic departments are embedded per the mission of research. Departments report through traditional academic line management channels (i.e., to department chairs and deans), thereby promoting line management control of research administration, though certainly not of the research itself. However, faculty members (or “PIs” in the chart) no less retain their autonomy. Faculty members who are also principal investigators (PIs) have their own small fiefdoms, sometimes organized into laboratory systems, and they have direct contact with research sponsors (typically federal agencies) rather than depending upon line administrators to broker those relations (Bozeman & Boardman 2003).

Organization charts help us to understand departmental “complexity” (Hall 2002). It is difficult, however, to infer from organization charts anything about departmental “centralization” (of the decision making process) and “formalness” (of rules and
procedures). The decision making process of academic departments has been characterized at practically every conceivable point along the continuum connecting extreme centralization (and formalness) with extreme decentralization (and informalness). Though some characterizations describe departmental decision making processes for workaday administration and curriculum management as “oligarchic” (Andersen 1976) and even as “feudal” or “caste based” (Crothers 1991), by and large empirical analyses describe departments’ decision making processes as “collegial” (Walvoord et al. 2000).

Based on interviews with 360 university scientists, Massy and colleagues (1994) characterize academic departments as “authentically collegial” where departmental faculty emphasize consensus, shared power, consultation, and collective responsibility in (mostly non research related) decision making processes (p. 18). However, many studies emphasize mixed models of decision making in academic departments. Toombs and Escala (1987) posit a mixture of collegiality and formalness. Bolman and Deal (1991) characterize tenure and promotion decisions as an oligarchic process but deem curricular decisions collegial. Daft and Bradshaw (1980) observe increased centralization with department size. Many of these studies equate the centralization of decision making with formal rules and procedures, though studies of the peer review process demonstrate that decision making in academic departments can indeed be decentralized but no less formal (e.g., Adkison 1976, Chubin & Hackett 1994).

Though academic departments seem quite variegated across a number of parameters, they seem less so after consideration of the characteristics common across centers.
Characteristics common across centers

Addressing characteristics common across university research centers may at first seem problematic given this study’s overarching focus on the impacts of institutional variation across centers on university scientists. Further, previous study emphasizes variation rather than consistency regarding the structure, functions, and other attributes of centers (e.g., Ikenberry & Friedman 1972, Geiger 1990, Stahler & Tash 1994). While centers certainly differ across numerous parameters, no less they share characteristics that help to distinguish them from academic departments.

Unlike with study of academic departments, there are numerous attempts to formally define centers (e.g., Becker & Gordon 1966, Ikenberry & Friedman 1972, Geiger 1990, Bozeman & Boardman 2003). This is probably because centers are relatively new phenomena when compared to departments (Stahler & Tash 1994) and, moreover, because they have been perceived as controversial (Mallon 2004) and even as revolutionary (Bozeman & Boardman 2004). However, many (though not all) definitions become vague once the task shifts from differentiating centers from departments to distinguishing centers from other extra departmental research units, such as institutes and laboratories (e.g., Geiger 1990). Most work on centers use these and like terms interchangeably (e.g., Ikenberry & Friedman 1972, Stahler & Tash 1994). Others use the blanket term “organized research unit” (e.g., Friedman & Friedman 1982).

Most attempts to define centers resort to listing attributes common across centers. Stahler & Tash (1994) list only one attribute, the conduct of research, in their admittedly “simplistic” definition (p. 541) and focus the remainder of their analysis on variation in external funding, number of faculty, separation from academic departments, integration
with the university, interdisciplinarity, emphasis on applied research, and so on.

However, a second inspection reveals much more than the authors suggest about centers’
shared characteristics. Centers, generally but to varying degrees, are funded by external
stakeholders, they are (typically) organizationally distinct from academic departments,
they are affiliated with universities, they retain as members faculty from more than one
discipline or field, they engage in applied or multidisciplinary or interdisciplinary or
problem focused research.

Other definitions explicitly include many of these characteristics (see Chapter 2).
The totality of these definitions suggests that the categories I employ (above) for
characterizing departmental attributes will also work when characterizing centers’
commonalities. The “practices” of centers may include (but are certainly not limited to)
the conduct of research in pursuit of a “mission” that is applied and problem focused and
multidisciplinary using “material arrangements” procured or paid for with monies from
external stakeholders, with whom center faculty and administration must “interact.”
Again, I qualify that though these categories are somewhat artificial, they remain useful
because they are amenable to differentiating centers from departments (in the final
section of this chapter). Further, I refrain from a thorough treatment of the differences
between centers and departments until the section following this one, though when
relevant in this section I certainly identify differences.

**Center practices**

Insofar as university research centers are academic units (usually) housed on a
university campus that retain as members university scientists who (typically) have
primary appointments in academic departments, upon first review center practices at first
seem not so different from departmental practices. By way of their faculty members (or
groups thereof), centers conduct and disseminate research, manage research projects and
funds, work to bring in additional funds for future research, perform administrative tasks,
perform university and community services, and so on. For certain subgroups of centers,
like Engineering Research Centers and Science and Technology Centers, student training
is an institutionalized practice (National Science Foundation 1996). Though center
practices can differ dramatically from one center to the next (Ikenberry & Friedman
1972), in practice centers no less share features not shared by academic departments. The
practices conducted within centers are not only different in scope than those conducted
within academic departments, but also different in scale insofar as center practices are
somewhat narrower or more restricted to research related activities (Ikenberry &
Friedman 1972).

Unlike (most) academic departments, centers conduct interdisciplinary and/or
multidisciplinary research.21 Though centers conduct their share of discipline based
“normal science” (Ikenberry & Friedman 1972, Bozeman & Boardman 2003),
interdisciplinary research has been regarded for some time as the primary justification for
centers’ existence (e.g., Becker & Gordon 1966, Ikenberry & Friedman 1972). I address
the varying degrees to which centers actually practice this type of research in Chapters 7
and 8. The point here is that if the practice was manageable by academic departments,
there would have been little impetus for the creation of centers. Related, centers conduct
“problem focused” research not often conducted in traditional departments, be it applied
work within the confines of a single discipline, interdisciplinary work, work driven

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21 Interdisciplinary is defined as faculty from different disciplines working together on the same project;
multidisciplinary is defined as faculty from different disciplines working independently on different aspects
of a project (Friedman & Friedman 1982).
exclusively by external stakeholder (usually industry) needs, or some combination thereof (Bozeman & Boardman 2003).

In practicing interdisciplinary and problem focused research, centers sometimes interact with external stakeholders different than those with which departments (typically) interact, usually (but not always) to transfer technology or knowledge or personnel outside the center and, further, outside the center’s home university. Along this line, Gray and colleagues (2001) characterize centers as “complex boundary spanning organizations that facilitate transactions between other organizations” (p. 248), in particular between academe and industry (Geisler et al. 1990). The practice of such external relations is mandated for some centers, such as Engineering Research Centers, which must practice joint research and other forms of technology transfer with private companies to retain support (National Science Foundation 1996).

Because centers’ external interactions do not necessarily materialize in the transfer or dissemination of research outputs, I designate the practice (somewhat differently than does the extant literature) as “interaction with external stakeholders” rather than as technology or knowledge transfer. Centers’ external relations need not be focused on transfers but rather can be informal encounters with no set objectives. Moreover, the practice need not be conducted exclusively with private companies but also may include scientists and other stakeholders outside the center but at the same university, at another university, at a federal laboratory or funding institution, and so on. However, when centers’ external interactions do carry with them “objects of transfer” (Bozeman 2000, p. 629), the objects are oftentimes students, faculty, varying forms of knowledge, and less frequently technology per se (Adams et al. 2001).
Centers conduct a variety of other practices, such as student training (in the laboratory, not the classroom) and mentoring, research administration, grants and contracts work, proposal writing; all of the practices one can envision occurring in an academic department save teaching (Bozeman & Boardman 2003). However, I do not discuss these practices here in that some are not common across a majority of centers (e.g., student training) and others, common or not, require no discussion beyond this brief mention (e.g., proposal writing). Certainly many of these practices are common across certain types of centers.

**Center missions**

It is both easier and harder to review the missions of university research centers than it is to review those of academic departments. Perhaps because they are relatively new and controversial when compared to departments (Mallon 2004), most centers and centers programs formally state their missions, a practice not common across departments (Hatfield 2000). Rather than lean on extant studies (as I do above for departmental missions) to piece together an idea of center missions, there exist actual mission statements to observe. This is the easy part. The hard part comes with identifying those components of center mission statements that do and do not represent the missions of the larger population of centers.

I start with the variegated mission of the Engineering Research Centers (ERC) Program. There are three main elements of the program’s mission, detailed in the table below.

<table>
<thead>
<tr>
<th>Mission</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-disciplinary and systems-</td>
<td>“Bringing diverse engineering and scientific disciplines together to address fundamental research issues crucial to the next generation of technological”</td>
</tr>
</tbody>
</table>
### ERC Program Missions

<table>
<thead>
<tr>
<th>Oriented Research</th>
<th>“Advances in areas that will enhance the international competitiveness in U.S. industry. A unique feature of ERC research is its integrated “engineering systems” perspective.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education and Outreach</td>
<td>“Producing a new generation of engineers who are adept at the cross-disciplinary team approach to problem solving; who understand and share industrial perspectives on research, design, and manufacturing; and who are well prepared to contribute immediately and productively to industry. An important feature is active outreach to involve faculty and students from other schools – including precollege students and teachers – in ERC research and education programs.”</td>
</tr>
<tr>
<td>Industrial Collaboration and Technology Transfer</td>
<td>“Maintaining a strong commitment to collaboration and technology transfer between the ERCs and their industrial partners. The primary emphasis is on ensuring that the research pursued at ERCs is relevant to industry needs and that its results are explored in experimental proof-of-concept testbeds designed to advance the competitiveness of U.S. industry in the global technological marketplace. The program requires active participation and long-term commitments from industry and other member organizations.”</td>
</tr>
</tbody>
</table>

*Source: National Science Foundation (1996), p. 3.*

It is quite obvious that the ERC Program’s mission is ambitious, plausibly much more so than those of most other university research centers. For instance, it seems unreasonable to suggest that common features across center missions are “to contribute immediately and productively to industry” and to “enhance the international competitiveness in U.S. industry” (National Science Foundation 1996, p. 3). However, embedded in the ERC mission are general concepts that help to distinguish center missions from those of (traditional) academic departments.

These general concepts are hard to distinguish from center practices, as was the case (above) with departmental missions. One needs only to acknowledge the left column of the above table. Center missions include the conduct of interdisciplinary research that helps to solve problems for an external stakeholder, all of U.S. industry in the case of ERCs, including some sort of transfer from the center to stakeholders, be it knowledge, technology, or trained students for hire. Accordingly, the generalized missions of university research centers boil down to the conduct of problem focused research and the transfer of the fruits of this research to those whose problems it can help to solve.
Whereas I do not classify “transfer” as a practice (above), I designate it a mission in that it is a major goal of the center practice of interacting with external stakeholders.

As with my characterization of center practices above, moreover, notice that I exclude education as a mission common across centers. While education is a major mission of large centers programs, education is a mission most (smaller and less complex) centers leave to the academic departments (Bozeman & Boardman 2003).

Ikenberry & Friedman (1972), in their study of “physical and life sciences,” “social sciences,” and “water” university research centers (p. 51), asked center directors for brief written descriptions of their centers’ essential missions. The results isolate research and public service as the primary missions of centers, even of those focusing on the social sciences. The authors also collected data to estimate the distribution of center resources across these missions and, in addition, that of student instruction. The distributions map with the center directors’ written statements, with research and public service combining to account for 93 percent of water centers’ resources, 77 percent of physical and life sciences centers’ resources, and 85 percent of social sciences centers’ resources.

Center material arrangements

Delineating the material arrangements common across centers is next to impossible. Depending on the type of research they conduct and for whom, centers may require laboratories or not, specialized instrumentation or not, common infrastructure such as office and meeting space or not. As I demonstrate below in Chapters 7 and 8, Schatzki’s (2005) “layouts and material connections” are not consistent across centers of the same type, such as across ERCs, much less across centers generally. The one
characteristic common across centers’ material arrangements that is not common across departments’ is utter inconsistency.

**Center interactive processes**

To assess the interactions of university research centers, I start with organizational structure (as I start when assessing departmental interactions). The organizational structures of centers vary tremendously (Ikenberry & Friedman 1972, Stahler & Tash 1994), much more so than do traditional departments’ (Mallon 2004). Such variation is encouraged even within specific centers programs. For instance, the “best practices” manual for Engineering Research Centers has this to say about organizational structure:

“There is no ideal organizational scheme for an ERC; every center will be (and should be) unique. Indeed, the creativity your ERC team brings to the development of the center is apt to serve as a model for future developments within your home institution. There are, however, two things you can count on: change, and the need to be flexible” (Engineering Research Centers Association, Section 6.2.1).

As with centers’ material arrangements, the only consistency in organizational structure across centers seems to be inconsistency. However, within specified centers programs review of centers’ internal organization charts reveal a moderate amount of consistency in both “complexity” and “centralization” (Hall 2002). Of course, these observations do not apply to the majority of centers that are not a part of any formal centers program and are much smaller in terms of personnel and resources.

Despite the “best practice” of “unique” organizational schema across Engineering Research Centers (Engineering Research Centers Association, Section 6.2.1), one can
observe consistency in how these centers organize internal interactions among their respective faculty, staff, management personnel, advisers, and university administration.

A review of every organization chart available (online) for currently “active” ERCs (as of April 2006, see http://www.erc-assoc.org/centers.htm) reveals what seems to be roughly the same internal structure.

Figure 6. Some organization charts from current ERCs

Source: http://erc.engin.umich.edu/files/industry/member/erc%20bylaws.pdf
Per these examples (and also per the ERC organizational charts not included here), organizational structure seems more “complex” (Hall 2002) than it does in
academic departments. Each chart reveals multiple management tiers between bench scientists and center directors, whereas academic departments typically have one or none separating department faculty members from the department chair. The complexity of ERCs’ internal organization seems more vertical than it does for departments, indicating plausibly less frequent interaction across the extreme levels of center management hierarchies. Again, these observations I make for illustrative purposes and do not apply to the large proportion of centers that have significantly fewer personnel and resources.

Also helpful in the task of distinguishing centers from departments is contrasting how centers fit into the larger organizational structure comprised of the university and also by external stakeholders (such as funding institutions and industry partners).

Figure 7. A generic conceptualization of the research management structure in which university research centers typically reside


This figure provides a simple model of the organizational structure in which university research centers are embedded per the mission of research. More so than departments, centers typically have more interaction with stakeholders external to the
university, including industrial partners, other universities, independent laboratories and principal investigators, and funding institutions. Centers also have more horizontal relations within the university, with academic departments and university administrators, because they draw resources on a “research problem basis” rather than on a disciplinary or traditional line authority basis (Bozeman & Boardman 2003, p. 19).

What all of this suggests is that center “complexity” (Hall 2002) is more hierarchical and also broader in scope than is departments’, at least for major centers programs like the Engineering Research Centers. Further, it suggests that centers are more centralized (during decision making processes) and also more formal (in terms of rules and procedures). There is evidence to support this case (e.g., Mallon 2004, Bozeman & Boardman 2003, Stahler & Tash 1994, Friedman & Friedman 1982, Ikenberry & Friedman 1972, Rossi 1964).

Numerous factors explain centers’ relatively high levels of centralization and formalness. First, center funding usually comes in the form of block grants instead of principal investigator grants (Bozeman & Boardman 2003). Moreover, center directors typically wield more authority than wield department chairs, which results in centers being much more the product of their respective directors’ goals and interests, more so than do departments become the brainchildren or “pet” projects of their respective chairs (Stahler & Tash 1994). The result is a governance structure distinct from that typically observed in academic departments, one that is significantly less “collegial” (Mallon 2004).

However, this line of reasoning does not necessitate center directors having more control over faculty than have department chairs. Interviews with center directors from a
field study of ERCs and Science and Technology Centers demonstrate the contrary. It is important to remember that most center directors have little or no role in tenure and promotion and sometimes little role in salary and performance deliberations (Bozeman & Boardman 2003). Further, they have relatively little with which to entice university scientists to conduct center based research:

“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.”

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

**Centers versus departments**

Thus far I have refrained from an extended comparison of centers to departments, though I certainly have made superficial comparisons between the two in terms of their respective practices, missions, material arrangements, and (internal and external) interactive processes. In doing this, I have taken liberty to generalize about both academic units despite evidence of much variation across each. The below table summarizes these generalizations.

Table 7. Summary of characteristics common across centers, across departments

<table>
<thead>
<tr>
<th>Practices</th>
<th>Centers</th>
<th>Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interdisciplinary research</td>
<td>• Student teaching</td>
<td></td>
</tr>
<tr>
<td>• Research dissemination</td>
<td>• Student advising</td>
<td></td>
</tr>
<tr>
<td>• Interaction with external (to the university) stakeholders</td>
<td>• Student evaluation</td>
<td></td>
</tr>
<tr>
<td>• Procurement of research funds</td>
<td>• Disciplinary research</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Research dissemination</td>
<td></td>
</tr>
</tbody>
</table>
Upon review of these differential characteristics, some “meta” differences become apparent.

**Priority**

The first has to do with priority. Whereas departments are primarily in the business of providing educational instruction to students, centers first and foremost conduct research (Bozeman & Boardman 2003). Without students there can be no academic department, but there may be a university research center. This has been more or less the case from the early days of university research centers. Using data from interviews with and survey responses of center directors, Ikenberry & Friedman (1972) demonstrate student instruction to be among the lowest priorities and research the highest
priority (in terms of resource allocations) for centers. Even for centers programs that emphasize student education and outreach, such as the Engineering Research Centers and Science and Technology Centers programs, student education is conducted via “live” research projects intended to benefit an external stakeholder or stakeholders (either in the long or short run).

**Management culture**

Another “meta” difference between the workaday operations of centers and departments is related to management. Center directors typically have appointments for indefinite or at least undefined terms that can usually be renewed without limit. The result is oftentimes a hierarchical organizational structure and authoritarian management culture (Mallon 2004), at least to the extent that this is possible when managing university scientists (Bozeman & Boardman 2003). Department chairs, in contrast, are usually elected for temporary, singular terms whereby the decision making process is consensus driven and collegial (Massy et al. 1994, Mallon 2004). The management cultures of centers and departments are amalgams of their respective interactive processes, and seem related to the degree to which each is insulated (or not) from external stakeholders, both within and outside the university, for instance by way of the presence (or lack) of executive boards, advisory committees, and so on (Geiger 1990).

**Degree of external influence**

Related to both priority and management culture is the degree to which external stakeholders influence the practices, missions, and organizational structures of centers and departments, usually by way of provision of research funding and other material
arrangements. Geiger (1990) places academic departments and university research centers on a continuum of external stakeholder influence:

Figure 8. Continuum for academic units

![Image of Continuum for academic units]

**Fig. 1. The Continuum for Sponsored Research**

*Source: Geiger (1990), p. 9.*

Academic departments’ external stakeholders (including the university and principal investigators’ funding institutions) are generally disinterested in research outputs (beyond ensuring that output is generated). Ignoring the distinction between centers and institutes (e.g., Stahler & Tash 1994), university research centers’ sponsors are interested in more than just generating output, but ensuring that this output has actual impact either in the long or short run. Though this distinction seems somewhat innocuous because in both instances research “happens,” it can affect, in conjunction with numerous other factors, the time allocations of university scientists. Differential norms and expectations regarding the research and numerous other tasks and duties expected of center scientists by both center and department can create “strain” whereby they allocate additional time to center tasks and duties in addition to time allocated to department based tasks and duties. I return to this theme later, when using role theory to formulate hypotheses in Chapters 6 and 8.
4. DISTINGUISHING THE CENTER ROLE FROM THE DEPARTMENT ROLE

Because roles first and foremost accomplish functions, they may be decomposed into their functional components (Biddle 1979). Identifying the functional components (i.e., the characteristic behaviors) of roles is an exercise in balancing parsimony with comprehensiveness. On the one hand one does not want to include behaviors that are not role specific. On the other hand, one must be careful not to omit behaviors that indeed are characteristic of a role, exclusive or inclusive, no matter how mundane. This task becomes all the more challenging when distinguishing between roles that are, functionally, quite similar and therefore may be characterized by many of the same behaviors. There is no requirement that roles be mutually exclusive; a role indeed can “integrate” or have significant “overlap” with another role (Biddle 1979). This is the key challenge when considering separately center affiliated scientists’ respective center and department roles.

Having demonstrated (in Chapter 3) that university research centers and (traditional) academic departments, as organizations, can be quite different from one another and therefore can expect quite different behaviors from their respective faculty members, I now make the case that center affiliated university scientists fulfill distinguishable, though quite similar, center and department roles. To do this, unlike most study of university faculty I emphasize “position” instead of “function” whereby the idea of “role” is used to highlight context related (albeit not entirely context based) variation in the workaday behaviors of university scientists (Biddle 1979). University research centers, after all, are first and foremost intended to induce in university scientists
behaviors typically not encouraged in the more traditional context of academic departments (Ikenberry & Friedman 1972).

Distinguishing the center role from the department role constitutes the foundation which underlay one of the chief arguments of this study: that “role strain” (between the center role and department role) sees center affiliated university scientists behaving differently than behave university scientists who do not affiliate with university research centers. Consider a hypothetical scenario wherein a center affiliated university scientist’s center director and center colleagues expect (of the center affiliated scientist) the conduct of collaborative research with industry scientists while the same scientist’s department expects the conduct of research that is more amenable to publication than to proprietary application, either alone or with departmental colleagues. Perhaps (because of research “double duty” or teaching “buyout”) this scientist teaches less but conducts more research than teach and conduct university scientists who do not affiliate with university research centers. Perhaps (because of network effects) the center affiliated scientist spends more time working in research groups and with researchers outside the university than she spends conducting research alone. Perhaps these differences change altogether once the center role is juxtaposed with other characteristics indicative of a university scientist’s “position” (Biddle 1979), such as tenure status.

I address formally the (potential) role strain induced by center affiliation (and the impacts thereof) in Chapter 5. The point here is to acknowledge that use of the role strain concept to predict and explain center affiliated university scientists’ behaviors requires demonstration that these scientists indeed play dual roles as faculty members in both university research centers and academic departments.
I rely on university scientists’ reports of their respective behaviors concerning (e.g., their respective time allocations to) research and research collaboration, teaching and student advising, grants and contracts work, and service and committee work, per the 2004 RVM Program Survey of Academic Researchers (see Appendix). I draw comparisons between respondents who indicate affiliating with a university research center and respondents who make no such indication. However, this type of analysis, while helpful, does not distinguish clearly the center affiliated university scientist’s center role from the same scientist’s department role. All it demonstrates is that center affiliated scientists behave differently than behave scientists who do not affiliate with centers.

To distinguish convincingly the center role from the department role, also required is data on the extent to which (if at all) center affiliated university scientists can themselves identify their center tasks and responsibilities as separate from their department tasks and responsibilities. Do center affiliated scientists conduct “center research” that is indeed different in content and purpose than (and therefore distinguishable from) their “department research?” Or is there considerable (if not complete) overlap between the two? Can these scientists make similar distinctions (or not) regarding the students that they mentor and teach? For this I employ data from more than twenty interviews with bench scientists working in National Science Foundation (NSF) Engineering Research Centers (ERCs) and Science and Technology Centers (STCs), all of whom at the time of the interviews were tenured or had tenure track appointments in academic departments (see Appendix).
The positional role

The first step to distinguishing roles is justifying one’s level of analysis (Biddle 1979). Some roles may be species wide, for instance when distinguishing human from animal behaviors, whereas other roles may be limited to a single person, for instance when identifying Lyndon Johnson as the only American president (regularly) to have held policy debriefings in Oval Office bathroom (Caro 2002). But the task of identifying the level appropriate for analyzing the roles of the university scientist is not so straightforward. Arreola and colleagues (2003) discuss the many roles of the “meta profession” of the professoriate, including distinguishable teaching, scholarship, and service roles. Studies of faculty time allocations make comparable role distinctions but do not distinguish conceptually between roles and behaviors (e.g., Milem et al. 2002). Paulson (2002) unbundles the teaching role into disparate though related “micro” roles of curriculum design, course development, teaching, tutoring, and student evaluation. Increasingly, industry interaction and technology transfer are considered important roles of university scientists (Bozeman 2000).

These examples point up the fact that in many (and probably most) cases, distinguishing “roles” from “behaviors” amounts to little more than semantics. Almost any level of distinction is acceptable insofar as one is clear in the terminology employed and, moreover, the distinction makes sense per the broader conceptualization and goals of the study at hand. In this study, I relegate the traditional “roles” of teaching, research, service, and the like to the status of “behaviors” that characterize the different and oftentimes competing roles that center affiliated university scientists play as faculty members of both university research centers and academic departments. This “positional
role” approach is common to the sociological study of the professions (Biddle 1997), one that emphasizes the importance of shared context and is therefore particularly amenable to the empirical components of this study (in Chapters 7 through 9) assessing the impact of center affiliation and institutional variation therein on the time allocations of university scientists. The positional approach, moreover, is more or less required to compare center scientists to their non center counterparts due to substantial “functional overlap” (Biddle 1979) between the tasks and duties expected of scientists by centers and those expected by departments.

**Behavioral measures in the 2004 RVM Program Survey of Academic Researchers**

In this section, from the 2004 Survey I use (absolute and relative) reports of the work time allocated to numerous academic tasks and responsibilities. I compare the time allocations of respondents who indicate affiliation with a university research center to the time allocations of respondents who make no such indication. ²² Though I posit that center affiliated university scientists fulfill separate center and department roles, this type of comparison emphasizes not that these roles are functionally distinct but rather that both roles are amalgamations of the same types of behaviors, albeit different proportions thereof. Both center affiliated and non center university scientists behave quite similarly. But the former, for instance, may teach less and collaborate more than the latter teach and collaborate. This type of comparison circumvents the problem that accompanies the use of statistical parameters to define roles. There is no need to delineate which behaviors constitute a “significant enough proportion” to count as a behavior that is characteristic of

²² In Section IV of the 2004 Survey, the respondent indicates whether he or she affiliates with a university research center, per the following definition: “A university research center is a ‘research institution that has five or more faculty and postdoctoral researchers and includes participants from more than one discipline and more than one academic department.”
a given role (Biddle 1979). All that matters here is the cross group comparison. Unless otherwise noted, the below discussed differences of means from center to non center scientists are statistically significant at the 10 percent level or greater.

**Research and research collaboration**

The data\textsuperscript{23} show that center affiliated university scientists, on average, work more on funded research projects than work their non center counterparts, but less on independent research projects. The mean hours per week allocated by center affiliated university scientists to grant supported research is approximately 14.5; the mean for university scientists not affiliated with a center is 12. The mean hours per week allocated by center affiliated university scientists to independent research is 3.8; the mean for university scientists not affiliated with a center is 5.4.\textsuperscript{24}

Figure 9. Time allocated to research

<table>
<thead>
<tr>
<th>Hours per average work week</th>
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<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td><strong>grant res.</strong>&lt;br&gt;center</td>
</tr>
<tr>
<td><strong>grant res.</strong>&lt;br&gt;non center</td>
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<tr>
<td><strong>ind. res.</strong>&lt;br&gt;center</td>
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<tr>
<td><strong>ind. res.</strong>&lt;br&gt;non center</td>
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</table>

Center affiliated university scientists’ demonstrate research collaboration patterns different from those of non center scientists.

\textsuperscript{23} See Section 3, Item 10 of the 2004 *Survey* for the survey item which elicited the time allocation data used in this chapter and subsequent chapters. The entire survey is reproduced in an Appendix below.

\textsuperscript{24} See the Appendix below for full descriptive data for each of the time allocation variables.
Figure 10. Research time allocated to collaborative research

Center affiliated university scientists allocate on average a substantial proportion, 51 percent, of their research related work time to working with researchers and graduate students in their “immediate work group, laboratory, or research center.” University scientists with no center affiliation also spend a significant proportion of their research time collaborating in this way, albeit at a smaller average work time allocation of 43 percent. Center scientists also spend more time working with researchers in industry (sample mean of 3.7 percent) than do non center scientists (sample mean of 2.8 percent). Conversely, center affiliated university scientists spend a smaller proportion of their research time working alone (sample mean of 11 percent) than do non center scientists (sample mean of 20 percent). The differences of means for center and non center scientists were not statistically significant for percentage of research time allocated to working with researchers in other universities nor for percentage of time allocated to working with researchers in government laboratories.
The data also show that center affiliated university scientists on average conduct research with more collaborators, no matter the type, than conduct scientists with no center affiliation.

Figure 11. Research partners

Center scientists partner in research activities more than partner non center scientists with both male (sample means of 6.7 and 4.1, respectively) and female faculty (sample means of 2.8 and 1.1, respectively) and also with more male (sample means of 3.9 and 2.7, respectively) and female students (samples mean of 2.1 and 1.2, respectively).

Teaching and student related behaviors

The data suggest that both center affiliated and non center university scientists allocate on average more time to teaching undergraduate students than they allocate to teaching graduate students, and more time to teaching undergraduate students than to advising both undergraduate and graduate students. However, the difference of means from center to non center scientists is statistically significant only for time allocated to teaching undergraduate students. Center affiliated respondents generally spend less time each week teaching undergraduates than spend their non center counterparts (sample means of 8.3 and 10.2 hours, respectively).
Grants and contracts related behaviors

Center affiliated university scientists on average allocate 5.9 hours per week to writing or developing proposals for grants and contracts; scientists who do not affiliate with centers allocate an average of 4.7 hours per week. Center scientists also allocate more time per week on average to grants and contracts administration (sample mean of 3.4 hours) than do non center scientists (sample mean of 2.1 hours).
Service and committee work

The average hours that center affiliated university scientists allocate per week to professional and community service work (that is not a part of their university based service and committee work) is 2.6 hours; for non center scientists 2.5 hours. The average hours per week that center scientists spend on university based service and committee work (be it related to their department and/or center) is 5.6 hours; 5 for non center scientists.

Figure 14. Service and committee duties

Proportional time allocations

The above descriptive analysis demonstrates that center affiliated university scientists spend more time than do non center scientists conducting grants based research, writing grants and proposals, and working on grants administration. It also demonstrates that center affiliated scientists spend less time than spend non center scientists teaching undergraduates and conducting independent research. Further, the two groups allocate roughly the same amount of time to performing service and committee work.

This characterization holds once the absolute terms presented above are converted to proportions of total weekly work time.
Figure 15. Proportional weekly time allocations of “non center” university scientists

The values for this table are mean values for variables that divide each respondent’s time allocation value for each of the activities by their respective total hours worked per week.

Figure 16. Proportional weekly time allocations of center affiliated university scientists

The values for this table are mean values for variables that divide each respondent’s time allocation value for each of the activities by their respective total hours worked per week.

Center affiliated scientists and non center scientists allocate, on average, the same proportion of their workaday lives to research (34 percent each), though the former
allocate a larger proportion to grants supported research and less to independent research than allocate the latter. Related, center scientists also spend more time than spend non center scientists writing or developing proposals for grants and contracts (11 percent versus 9 percent, respectively) and administering grants and contracts (6 percent versus 4 percent).

Center scientists on average do not allocate as large a proportion of their time to teaching as allocate non center scientists (27 percent versus 32 percent, respectively), with the difference explained solely by center scientists allocating a smaller percentage of time to teaching undergraduates (15 percent versus 20 percent). Center scientists and non center scientists, moreover, allocate approximately the same proportions of time to university based service and committee work. The differences for the percentage of time allocated to teaching graduate students, student advising, performing non university service and committee work, and paid consulting are not statistically significant.

This type of analysis, however informative, does not distinguish clearly the center affiliated university scientist’s “center role” from the same scientist’s “department role.” Though observing behavior is perhaps the most direct way to identify behaviors characteristic of roles (Biddle 1979), all that has been demonstrated thus far is that center affiliated scientists behave differently than do scientists who do not affiliate with centers. To strengthen the case that center scientists indeed fulfill dual roles as members of both academic departments and university research centers, I rely on interviews wherein I ask center scientists directly whether or not they can distinguish between their center based tasks and responsibilities and their department based tasks and responsibilities.
Center scientists’ distinctions between the center role and department role

At best, the above analysis demonstrates tenuously the possibility that distinguishable center and department roles exist. Center affiliated university scientists allocate their work time differently and collaborate in different ways than allocate and collaborate university scientists with no center affiliation. Required, however, is evidence that center scientists themselves consider these roles to be separate. If center scientists do not distinguish their workaday activities and tasks in this way (i.e., positionally rather than functionally), the theoretical underpinnings of this study unravel. The ability of center scientists to distinguish their center from their department tasks and responsibilities is vital to the argument that role strain (between center demands and expectations and department demands and expectations) sees center affiliated university scientists behaving differently than behave university scientists who do not affiliate with university research centers.

In extended interviews (lasting 1 to 1.5 hours each), I asked twenty one tenured or tenure track scientists working in National Science Foundation (NSF) ERCs and STCs, among other questions, to identify per a Likert-type scale (wherein 1=Strongly Agree, 2=Agree Somewhat, 3=Disagree, 4=Strongly Disagree) the extent to which they distinguish their department tasks and duties, research and otherwise, from their center tasks and duties, research and otherwise (see Appendix). The tasks and duties discussed included 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”).

The reasoning that underlay these questions was that interviewees indicating a high level of agreement with these statements would be more likely to report having experienced center induced role strain than would respondents disagreeing with these statements. Clearly distinguishable tasks and responsibilities beget clearly distinguishable and therefore potentially competing roles. The responses, because they are based on interviews with center scientists themselves, constitute “subjective” potential for center induced role strain (Pandey & Kumar 1997, Kahn et al. 1964).25

To further clarify the extent to which center affiliated university scientists can distinguish their center from their department tasks and responsibilities, I asked the same interviewees (using the same Likert-type scale) about center versus department expectations regarding industry interaction (“Interacting with industry is a center, not a departmental, expectation”) and also 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 likelihood of center induced role strain.26

A majority of the interviewees could distinguish on at least one count (i.e., research, articles, grants, or students) their department tasks and responsibilities from

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25 Evidence of role strain may be “objective” (Pandey & Kumar 1997, Rizzo et al. 1970) via observation of components of center scientists’ work environments that are indicative of role strain or “subjective” (Pandey & Kumar 1997, Kahn et al. 1964) via center scientists’ reports of misalignment or conflict between their centers’ expectations and demands and their departments’ expectations and demands. I review these and related concepts in Chapter 1.

26 I discuss the concept of center induced role strain and test it empirically in Chapter 5.
their center tasks and responsibilities. For instance, typical of the findings is the report of a full professor and biochemist working in an ERC:

“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.”

However, there were a handful of interviewees who could make no such distinctions. An assistant professor and mechanical engineer, working in another ERC, reported regarding her 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.”

Evident in the interview results are a few trends. First, the interviews demonstrate a consistent, positive relationship between the ability to distinguish center research from departmental research and the ability 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” reported the same regarding the research he conducts. In quite fewer instances, interviewees reported the inverse (no less still positive) relationship. A full professor and neuroscientist reported that his center and departmental research were “one and the same,” as were his publications. I did not observe this sort of positive alignment for other combinations of academic tasks and responsibilities. Further, few center scientists reported that they could distinguish their center duties from their department duties on all four counts (of research,
articles, grants, students). However, more than half of the interviewees made the
distinction for two or more of these activities, and more than three quarters made the
distinction for at least one.\textsuperscript{27}

Regarding center versus department expectations of industry interactions and
collaboration with researchers at other universities, the results are mixed. About half the
interviewees indicated “agreeing” or “strongly agreeing” that industry interaction was a
center expectation and not a departmental one.

\textit{“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.”}

Others indicated that such interactions were facilitated but not necessarily “expected” by
their centers.

\textit{“I would say the center has facilitated my interaction with industry, I’m
not sure that they have the expectation that all of us in the center would
have that kind of interaction. But when I’ve wanted it, it has happened
because of the center.”}

The results were similar for collaborations with researchers at other universities. Some
agreed but many more disagreed that such collaborations were center rather than
departmental expectations. One respondent notably protested that such collaboration was
a personal expectation and not one harbored by her center or her department.

\textsuperscript{27} Summing the number of responsibilities for which university scientists can distinguish their center from
department duties, 7 respondents reported that they could make the distinction on all four counts (research,
articles, grants, students), 2 respondents reported on 3 of 4 counts, and 2 more reported on 2 of 4 counts the
ability to distinguish center from departmental duties.
Perhaps the most significant trends in the interview data have to do with individual level and institutional level variation in the interviewees and their centers, respectively. The interview data show no individual level consistency in the ability (or lack thereof) to distinguish one’s center and department roles. Some junior level (tenure track but not yet tenured) biologists could do so, others could 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 all of the interviews, I found no consistency in reports of the ability to make the distinction across a broad array of personal and professional characteristics, including gender, discipline, having tenure, length of tenure in the center and department, as well as whether or not the scientists must perform for center, in addition to research, 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.

However, at the institutional level of analysis, the ability to distinguish one’s center and department roles becomes more “predictable.”

University scientists who could not distinguish their center and department tasks and duties were working in centers that had made connections to their academic departments (as perceived by the interviewees). University scientists who had little problem making the distinction did not mention such connection. From the modest number of interviews, there was quite a lot of variation in the ties between interviewees’ centers and departments. At one extreme, the

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28 I use quotations because the interview subjects do not represent a random sample of center scientists but rather case study of scientists from particular NSF centers. The goal of the interviews was not to arrive at generalizations about center scientists but rather to develop a story around the dual obligation that many center scientists face to center and department.
center constituted but a subunit of the academic department, with the department head having managerial authority over center research and related activities. At the other extreme, the center seemed to have no ties whatsoever with interviewees’ home departments.

My goal for this qualitative section is certainly not to generalize from such a small and nonrandom set of center scientists. No less the results render more plausible the idea that center affiliated university scientists fulfill separate center and department roles. Many interviewees could distinguish their research, advisory, grant proposal, and publication activities along center and departmental lines. I return to many of these findings (in addition to other findings from the same interviews, presented in Chapter 5 on role strain) when formulating hypotheses regarding the impact of institutional variation across centers on the behaviors of the scientists who affiliate with them (see Chapters 6 and 8).

**The center role, the department role, and tenure status**

Distinguishing the center role from the department role constitutes the foundation which underlay the proposition that “center induced role strain” sees center affiliated university scientists behaving differently than behave university scientists who do not affiliate with university research centers. If anything is worth taking away from the literature on the “meta profession” of university scientists (Arreola et al. 2003), however, it is the truism that university scientists, center affiliated or not, play numerous roles, more than the center and department roles that are the focus of this study. In this section I use the 2004 RVM Survey data as I use it above, this time controlling for tenure status when analyzing differences between center and non center scientists. I assess tenure
status because having tenure has been shown to affect university scientists’ time allocations (Jacobs & Winslow 2004). Whether or not tenured or untenured but tenure track statuses constitute additional “positional” roles (i.e., the role of “junior” faculty versus the role of tenured faculty) that university scientists can fulfill is not a primary concern. More interesting is that the above demonstrated differences between center and non center scientists holds (in terms of statistical significance and direction) within the sub groups of tenured versus untenured but tenure track university scientists.

**Proportional time allocations**

The proportional time allocations for center versus non center scientists, regardless of tenure status, demonstrates that center affiliated university scientists spend more time than spend non center scientists conducting grants based research, writing grants and proposals, and working on grants administration. It also demonstrates that center affiliated scientists spend less time than spend non center scientists teaching undergraduates and conducting independent research. Further, the two groups are shown to allocate roughly the same amount of time to performing service and committee work.

Most of this characterization holds for sub samples of tenured and of untenured but tenure track university scientists.
Figure 17. Proportional weekly time allocations of center affiliated university scientists who are untenured but tenure track

![Pie chart showing time allocations]

The values for this table are mean values for variables that divide each respondent's time allocation value for each of the activities by their respective total hours worked per week.

Figure 18. Proportional weekly time allocations of non center university scientists who are untenured but tenure track

![Pie chart showing time allocations]

The values for this table are mean values for variables that divide each respondent's time allocation value for each of the activities by their respective total hours worked per week.
For the sub sample of untenured but tenure track or “junior” scientists, center affiliated scientists allocate, on average, a larger proportion of their weekly work hours to grants based research than allocate non center scientists (28 percent versus 26 percent, respectively), and they allocate a smaller proportion to independent research (9 percent versus 13 percent). Related, center scientists who are untenured also spend more time than spend their non center counterparts writing or developing proposals for grants and contracts (13 percent versus 11 percent) and administering grants and contracts (5 percent versus 4 percent).

The only deviation (in terms of the statistical significance and direction of the center versus non center comparison) between these differences of means for research and research related activities and those presented above for the entire sample of scientists is for the proportion of time allocated, on average, to research of any type (i.e., time allocated to grant research plus that allocated to independent research) each week. For the sub sample containing junior scientists only, this figure is actually larger for non center scientists than it is for center affiliated scientists, because the difference of means for the time allocated to independent research is greater in the sub sample than it is in the entire sample.

Sticking with the sub sample of junior scientists but turning towards time allocated to “non research” academic work, untenured center scientists on average do not allocate as large a proportion of their time to teaching as allocate non center scientists (30 percent versus 33 percent, respectively), with the difference explained (as it is explained for the entire sample above) solely by center scientists allocating a smaller percentage of time to teaching undergraduates (16 percent versus 21 percent). Untenured center and
non center scientists, moreover, allocate on average approximately the same proportions of time to university based service and committee work. The differences for the percentage of time allocated to teaching graduate students, student advising, performing non university service and committee work, and paid consulting are not statistically significant. As is the case with time allocated to research activities, for the sub sample of junior scientists there is no deviation between these differences of means (in terms of the direction of the center versus non center comparison) and those presented above for the entire sample of scientists.

There is little difference for the sub sample of tenured scientists as well.

Figure 19. Proportional weekly time allocations of center affiliated university scientists who are tenured

The values for this table are mean values for variables that divide each respondent’s time allocation value for each of the activities by their respective total hours worked per week.
For the sub sample of tenured scientists, center affiliated scientists allocate, on average, a larger proportion of their weekly work hours to grants based research than allocate non center scientists (27 percent versus 24 percent, respectively), and they allocate a smaller proportion to independent research (6 percent versus 9 percent). Related, center scientists who are tenured also spend more time than spend their non center counterparts writing or developing proposals for grants and contracts (10 percent versus 8 percent) and administering grants and contracts (7 percent versus 4 percent). Tenured center scientists on average do not allocate as large a proportion of their time to teaching as allocate non center tenured scientists (27 percent versus 32 percent, respectively), with the difference explained solely by center scientists allocating a smaller percentage of time to teaching undergraduates (15 percent versus 20 percent). Tenured center and non center scientists, moreover, allocate on average the same proportions of
time to university based service and committee work. The differences for the percentage of time allocated to teaching graduate students, student advising, performing non university service and committee work, and paid consulting are not statistically significant. For the sub sample of tenured scientists, as with the sub sample of untenured scientists, there is no deviation between these differences of means (in terms of the direction of the center versus non center comparison) and those presented above for the entire sample of scientists.

With these comparisons I do not intend to suggest that tenure status is not an important characteristic or even an important “positional” role (Biddle 1979) to consider when studying the roles of center scientists and how these roles may influence time allocations. The econometric analyses of university scientists’ time allocations (in Chapters 6 and 8) demonstrate tenure status to be a strong predictor of time allocated to research, teaching, and to university service. The point here is that in addition to tenure status and numerous other individual characteristics, center affiliation can affect systematically the way scientists allocate work time to their numerous academic duties.

**Conclusion**

Having demonstrated that center affiliated university scientists behave differently (i.e., allocate their work time and collaborate differently) than behave (i.e., than allocate and collaborate) university scientists who do not affiliate with university research centers and, further, having demonstrated (in this chapter) that it is not extraordinary for center scientists to distinguish their center tasks and responsibilities from those they fulfill for their academic departments, the argument that center scientists play distinguishable center and department roles is rendered plausible. Missing from the analysis thus far,
however, is explanation as to how center and department roles affect the university scientists who fulfill them simultaneously.
5. CENTER INDUCED ROLE STRAIN

Previous study of university research centers suggests commonplace if not frequent friction between centers and departments regarding the scarce resource of faculty time. Geiger (1990) describes center-department relations as “tension-prone and symbiotic” in his discussion of the “dual orientation” of center affiliated university scientists (p. 10). Stahler and Tash (1994) cite center-department clashes over not just faculty time, but also over internal funding support, space, equipment and research infrastructure, and credit for grants and for research outputs. Bozeman and Boardman (2003) discuss the “double duty” that center scientists must perform per their respective center and departmental assignments (p. 29).

The idea of (probable though not ensured) tension between centers and departments logically follows from this study’s analysis thus far. While centers and departments share faculty, they do not share much else, for example in terms of mission (see Chapter 3). University scientists who can distinguish their respective center roles from their department roles are caught between two disparate but legitimate sources of demand for their work time, each harboring distinct norms and expectations (see Chapter 4). Accordingly, these scientists may experience role strain, which occurs when the norms and expectations of one role sender diverge from the norms and expectations of another (see Chapter 1), and thereby experience “difficulty” (Merton 1957, Goode 1960) in fulfilling this dual obligation insofar as they must allocate additional work time
(MacKinnon 1978) to fulfill center tasks and duties on top of the time they allocate to fulfill department tasks and duties.\(^{29}\)

Role strain, induced by center affiliation in (many but certainly not all) center scientists, constitutes an important part of the operation or “mechanism” (Lin 1998) that underlay variation in the work time allocations of center scientists. Though alternate explanations of time allocations that emphasize increased returns or gain rather than strain (e.g., Rosen 1974, Jacobs & Winslow 2004, Corley & Gaughan 2005) are valid and in fact predominant, the two approaches need not be contradictory. When taken together, they help to provide a more comprehensive explanation of center scientists’ time allocations across their academic tasks and responsibilities.

Required, then, is analysis of the extent to which center affiliated university scientists actually experience role strain when fulfilling their center and department roles. Also required is analysis of any individual level or center level factors that seem to correlate with reports of role strain. The data I use to meet these requirements come from the twenty one interviews (with ERC and STC affiliated scientists\(^{30}\)) introduced in the

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\(^{29}\) This argument is similar to the one made at the institutional level by Becher and Kogan (1992), who suggest that institutional innovations can create “pressure” on the norms and operations of academic units and, further, that such innovations can result in a “failure to satisfy internal academic norms” (p. 145). Different here is the object – the individual scientist rather than the academic unit – upon which new institutional forms may apply pressure. Different as well is what changes as a result of this pressure. Rather than the norms internal to academic units changing, it is the norms of a new institution changing the behaviors of faculty members.

\(^{30}\) The NSF centers with which these interviewees affiliate are of especial interest regarding the idea of role strain, not only because ERCs and STCs require their respective faculty members to occupy a tenured or tenure track appointment in an academic department, but also because these centers are among the most complex of university research centers. Whereas most centers are relatively simple in structure (Gaughan and Bozeman 2005) and may not be all that different than academic departments (Ikenberry & Friedman 1972), ERCs and STCs qualify as both “multipurpose” and “multidiscipline” (Bozeman and Boardman 2003) and retain as distinctive characteristics: (1) the mixing of disciplines and scientific fields, (2) extensive interaction with institutions external to the university, including private companies as well as other universities, and (3) a blending of diverse research missions with outreach, including technology transfer or technical assistance. Though I address systematically institutional variation across university research centers in the Chapter 7, here the point is that study of ERC and STC affiliated scientists is
previous chapter (to distinguish the center role from the department role). The interview responses constitute “subjective” indication of center induced role strain (Pandey & Kumar 1997, Kahn et al. 1964).³¹ Before proceeding to the interviews, I first review the basics of the role strain concept as well as its application in previous study of scientists.

**Intra versus inter organizational role strain³²**

The idea that university scientists may experience role strain is not new. Role strain within academic departments, concerning the functions or behaviors of teaching and other non-research tasks in addition to scientific work, is already a chief concern (e.g., Bowen & Sosa 1989).³³ Academic departments expect multiple behaviors that sometimes compete or conflict, thereby creating intra institutional role strain. This is the type of role strain assessed in the early organizational stress literature which may occur regardless of whether a university scientist affiliates with a center. Further, intra institutional role strain can occur within centers. Like departments, centers expect of their faculty numerous behaviors that may sometimes compete or conflict. Though I review perhaps more illustrative regarding center induced role strain than would be study of scientists who affiliate with “smaller” centers (employing fewer resources to focus on a single research problem with scientists from fewer disciplines or even from within just a single discipline).

³¹ Evidence of role strain may be “objective” (Pandey & Kumar 1997, Rizzo et al. 1970) via observation of components of center scientists’ work environments that are indicative of role strain or “subjective” (Pandey & Kumar 1997, Kahn et al. 1964) via center scientists’ reports of misalignment or conflict between their centers’ expectations and demands and their departments’ expectations and demands. I review these and related concepts in Chapter 1.

³² 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. I prefer the role strain label inasmuch as conflict often implies active disagreements among parties whereas role strain generally pertains to perceptions of individuals occupying a particular role. Generally, role strain refers to the circumstance in which individuals are subject to competing demands in the workplace, in the home, or elsewhere.

³³ There also exists a substantial body of study on the multiple expectations that academic departments have of their scientists that does not employ the sociological lens of “role strain.” Many of these studies promote alteration of the academic reward system to give equal (or at least more) weight to non-research activities such as teaching (Geisler 1989, Boyer 1990, Diamond 1993, Diamond 1999, Braxton & Del Favero 2002).
above (in Chapters 3 and 4) the numerous practices and behaviors characteristic of centers and departments and of the scientists who work therein, I am not concerned with intra institutional role strain, either in centers or departments, as it has existed as long as have universities (at least in academic departments) and is adequately addressed by the classic role assessments of professional scientists (e.g., Merton 1957).34

As the overarching purpose of this study is to assess the impact of institutional design on the time allocations of university scientists, in this chapter the focus is on the _inter_ organizational role strain that may be induced in university scientists when they affiliate with centers in addition to working in academic departments. This focus places especial emphasis on position rather than function (see Chapter 4), drawing on Merton’s (1957) early conceptualization of role strain as a structurally induced circumstance and on other study (e.g., Biddle & Thomas 1966, Biddle 1979, Biddle 1986) of role strain emphasizing context and the interplay between context and individual values. Accordingly, this focus emphasizes the “inter sender” and “inter role” dimensions of role strain introduced in the Chapter 1 introduction.

**The logic of role strain as it has been applied in previous study of scientists**

Role theory posits that if an individual takes on multiple roles, that individual may experience role strain, which has been defined as “felt difficulty in fulfilling role expectations” (Goode 1960, p. 483). Merton (1957) first introduced the concept, identifying role strain as “the structural circumstance that anyone occupying a particular status has role partners who are differently located in the social structure” (p. 370-71). For this study it is the center scientist who has multiple “role partners” (often called “role

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34 “Intra organizational” role strain is analogous to the “intra sender” dimension of role strain (Pandey & Kumar 1997) described in Table 1.1 of the Chapter 1 introduction.
senders” in the empirical literature) who are “differently located in the social structure” of the university. The different locations are the academic department and university research center. Because I review in Chapter 1 the general “operation” of roles and how this may lead to one or more dimensions of role strain, in this section I focus specifically on how the concept of role strain has been used previously to study the behaviors of scientists.

Goode (1960) and others concerned specifically with the work experiences and work environments of scientists (e.g., Evan 1962, Box and Croton 1966) employ the concept of role strain as an economic or rational function wherein individual scientists minimize to the greatest extent possible the amount of role strain they must endure in their respective work environments. Box and Croton (1966) suggest that scientists do this by choosing to work for the type of research organization, or more precisely for the sector of research organization (i.e., university, industry, government), which holds expectations that best match their own expectations, thereby increasing to the greatest extent possible the utility they may derive from their careers as professional scientists. For instance, scientists who want to publish their results work in academia, scientists who want to develop patents and prototypes work in industry. The key similarity between these early studies and the current study is the conceptualization of role strain as a “structural circumstance” (Merton 1957, p. 483) indicating the conflict that exists (or not) between one set of norms and expectations and another. But this is where the similarities end.

The logic of “role strain minimization” emphasized in the early literature must be altered if not entirely deemphasized to assess university scientists who fulfill distinct center and department roles. For the center scientist, role strain minimization is not a key
factor (as center affiliation is “voluntary”), but rather one of many factors to consider when deciding to affiliate with a center.35 Despite the disparate authority lines and reporting relationships centers pose (see Chapter 3), many university scientists opt to add center work to their departmental workload, potentially increasing the respective levels of role strain to which they are exposed (Boardman & Bozeman, forthcoming).

This difference (between early study and the current study) may be explained by the sources of the norms and expectations that are strained or in conflict. The early studies assess strain between individual scientists’ values and expectations and the values and expectations of the organizations that employ them. These studies are therefore focused on the intra sender dimension of role strain (see Chapter 1) and emphasis on the minimization of role strain seems an adequate approach towards explaining scientists’ decisions to work in academia versus industry, and vice versa. The current study, however, assesses strain not between the values and expectations of individual scientists and those of the organizations that employ them, but rather between the values and expectations of two distinct organizations, the center and department, both of which have legitimate claim on individual scientists’ work time and energy. The current study is therefore focused on alternate dimensions of role strain which cannot be (so easily) governed by the individual scientists themselves.

Center affiliated scientists may experience different dimensions of strain as a result of fulfilling simultaneously center and department roles. They can experience

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35 The “voluntary” affiliation with centers 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 and Boardman, 2003 for an overview) suggest that affiliation is in most cases voluntary, even in the strict sense of that term. I discuss the reasons university scientists affiliate with centers despite the role strain it exposes them to below.
“inter role” role strain when their role senders, the center and the department, expect of them behaviors that are incompatible or at least in competition with one another (Kahn et al. 1964). Consider, for instance, the differences in center versus departmental missions discussed above (in Chapter 4). Center research is almost always organized by problems (e.g., earthquakes, semi-conductor packaging, tissue engineering) and aimed at application or perhaps even commercial development. The traditional academic department, in contrast, is organized by discipline (e.g., geology, physics, chemistry) and concerned primarily with the extension of basic knowledge and publication in peer reviewed media. This is not inconsistent with Evan (1962), who conducted a study of “inter role” role strain in professional scientists determining that reports of role strain vary according to the character of the research performed by the scientist.

University scientists who fulfill distinct center and department roles also may experience “inter sender” role strain (Kahn et al. 1964). University scientists experience this dimension of strain when role expectations from equally (or comparably) legitimate role senders create the problem of work overload (MacKinnon 1978), no matter if “inter role” role strain occurs. The only criterion is center work constituting additional (though not necessarily incompatible or conflicting) work that a scientist must perform in addition to the tasks and duties she performs for an academic department. This is not inconsistent with Bozeman & Boardman (2003), who find that center affiliation sees university scientists performing “double duty” for numerous academic tasks and duties.

Taken together, the “inter sender” and “inter role” dimensions of role strain can 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 either through lost research dollars or the lost time of researchers (Stahler & Tash 1994). Department faculty who have grants and contracts with a center not only have less time for research and publishing within their own discipline, but also are less likely to be available to teach the department courses for which students have paid tuition and are less likely to have sufficient time for such organizational maintenance activities as hiring and promotion committees (Bozeman & Boardman 2003). I review the details of these concepts and the previous studies that employ them as they relate to my presentation and analysis of the interview data below. It is important to note that, because interview data is used, role strain here is conceptualized “subjectively” (Pandey & Kumar 1997, Kahn et al. 1964) as individual scientists’ reports of center induced role strain rather than “objectively” (Pandey & Kumar 1997, Rizzo et al. 1970) as observable components of a center scientists’ work environments that are amenable to role strain. The latter conceptualization is reserved for Chapters 7 and 8 on institutional variation across centers.

**Operationalizing “center induced role strain”**

The interview protocol’s operationalization of role strain (see Appendix) includes items about the “inter role” and “inter sender” dimensions of role strain. In this section I review the protocol items designed to elicit responses that indicate instances of center induced role strain. I review the interview responses in the following section.

**“At risk” university scientists**

Before asking the interviewees about incidences of center induced role strain, the interview protocol was designed to determine whether they are “at risk” of experiencing
role strain by asking them to indicate on a Likert-type scale\textsuperscript{36} the extent to which they could distinguish their departmental duties, research and otherwise, from their center duties, research and otherwise. This is the data used above (in Chapter 4) to help support the proposition that center scientists fulfill separate center and department roles. The informal hypothesis is that higher levels of agreement indicate a higher “risk” of experiencing (and therefore a higher probability of reporting having experienced) center induced role strain.

**“Indirect” indicators of role strain**

After determining which scientists are more likely to report experiencing role strain, the protocol contains items asking interviewees indirectly about any conflicts amongst the many tasks and behaviors expected of them by their respective departments and centers. I asked interviewees whether their departments reacted “positively,” “negatively,” or “with ambivalence” to tasks that they indicated earlier in the interview having performed for their center, including 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. Negative responses constitute “indirect” evidence of center induced role strain.\textsuperscript{37}

Another “indirect” indicator of role strain included in the interview protocol is an item about departmental reward and punishment. It asks respondents “What center work, if any, does your department acknowledge, reward, or punish?” Though quite similar to

\textsuperscript{36} 1=Strongly Agree, 2=Agree Somewhat, 3=Disagree, 4=Strongly Disagree.

\textsuperscript{37} I 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. Moreover, this evidence presumes accurate respondent perceptions of departmental attitudes and behaviors towards their center related activities.
the survey item just reviewed, this one is designed to elicit an open ended response that may cover activities beyond research, publication, administrative and committee work, student mentoring, and grants work. “Punishment” responses constitute additional “indirect” evidence of center induced role strain.38

For both “indirect” items, the interview protocol also implements the questions in reverse, asking about center attitudes, approaches, and policies towards the tasks and duties center scientists perform on behalf of academic departments. Similarly, “negative” and “punishment” responses are interpreted as “indirect” evidence of center induced role strain.39

“Direct” indicators of role strain

After indirectly assessing the role strain experienced by center affiliated university scientists, the interview protocol asks “direct” questions about role strain, questions reminiscent of the classic studies on the topic. Respondents are asked “Do you ever feel that your center 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, the protocol probes as to the specific nature of the conflict or strain, in particular whether it is owing to an obligation to disparate but legitimate demands on their work time (“inter sender” role strain) or to an obligation to perform tasks that are substantively different and potentially conflicting or incompatible

38 Again, this evidence is indirect because of the assumption that perceptions are reflective of reality and also because of potential response bias or other problematic phenomena specific to survey and interview data gathering methodologies.

39 With respect to the “indirect” protocol items I consider responses that indicate (albeit indirectly) role strain to be “center induced” not because of attitudes or expectations emanating from a center, but because center scientists would not experience such strain if they did not affiliate with a center. That said, by “center induced role strain” I mean “center affiliation induced role strain.”
(“inter role” role strain). Unlike the questions for the “indirect” indicators, these questions were implemented to elicit open ended responses only.

**Interview results**

In my presentation of the results I employ a macro approach (considering any consistencies or lack thereof across the interviewees’ responses) and a micro approach wherein I present and discuss in detail the responses of individual interviewees. I qualify that from these results I do not intend to generalize, but rather to construct multiple stories describing when center scientists experience center induced role strain and when they do not, at least in the context of large scale centers programs such as those managed by the NSF.

At the outset of this study I expected university scientists who could more easily distinguish between their departmental and center duties, those I consider above to be “at risk,” to be more likely to report experiencing center induced role strain. I also expected that university scientists working in departments that react negatively to or that employ negative incentives regarding center related tasks and activities (per the above “indirect” indicators) to be more likely to report having experienced strain. The rationale underlying these expectations was that a center scientist’s ability to distinguish her center from department work as well as her perception of departmental resistance to her performance of center work would be more likely in the “structural circumstance” (Merton 1957) of role strain wherein centers and departments hold divergent expectations of their scientists. This is what the interview data generally reveal.
Which center scientists experience role strain?

I briefly take a macro approach to the interview data to identify any trends in reports of role strain. One would expect to see certain trends, for instance when comparing tenured faculty to their untenured but tenure track counterparts. However, the interview data showed no individual level consistency in reports of role strain. Some junior level biologists experience role strain, others do not. Some tenured engineers report conflicting demands on their work time while other engineers with tenure cannot. In all of the interviews, I find no consistency in “direct” or “indirect” reports of role strain across a broad array of personal and professional characteristics, including gender, discipline, having tenure, and length of tenure in the center and department. Similarly, the results demonstrate no coincidence of reports of role strain and the extent to which respondents felt either encouraged or discouraged by their departments to affiliate with their center.

As with my review (in Chapter 4) of the ability of center scientists to distinguish their respective center from department tasks and duties, at the institutional level of analysis reports of role strain become more “predictable.” For those scientists reporting role strain, there exist more “formalized” network ties connecting their respective centers and departments (as perceived by the interviewees) than exist for scientists making no reports of role strain. From the modest number of interviews, I 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

40 I use quotations for the same reason I use them in Chapter 4. Because the interview subjects do not represent a random sample of center scientists but rather case study of scientists from particular NSF centers, no formal predictions can be made using the interview data alone. The goal of the interviews was not to arrive at generalizations about center scientists but rather to develop a story around the dual obligation that many center scientists face to center and department.
research and related activities. Reports of role strain in this and like instances are practically non existent. At the other extreme, the center seems to have no ties whatsoever with its faculty affiliates’ home departments. Reports of role strain in this scenario become commonplace, though not ensured.

**“Indirect” indicators of role strain**

In some cases university scientists who are “at risk” of role strain did not respond as I expected to the questions designed to “indirectly” indicate instances of center induced role strain. Generally, respondents who could distinguish between their center and department tasks and duties (see Chapter 4) indicated that their academic departments viewed their work on center based publications either “positively” or “with ambivalence” (versus “negatively”). Here is a comment typical of center scientists providing “with ambivalence” responses:

> “The department doesn’t respond. They don’t recognize [center-based publications] as being different than [departmental publications].”

> “The department doesn’t have any formal measurements or non measurements for center publications... It really is fairly agnostic.”

A comment typical of center scientists providing “positive” responses:

> “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 non finding perhaps may be explained by academic departments’ heavy weighting of publications during tenure and promotion decisions. Also along this line, “at risk”

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41 In the question I asked interviewees to indicate department attitudes towards their center work as “positive,” “negative,” or “ambivalent” (see Appendix).
scientists typically gave “positive” responses regarding their departments’ attitudes towards their work on center based proposals and grants, again both outputs coveted by academic departments.

Many (though not all) of the “at risk” interviewees had “negative” responses (indicating the perception of department dissatisfaction with time allocated to center related work) regarding mentoring center students who do not belong to the department, working with industry in a non departmental capacity, and performing service and committee duties for the center. A typical comment accompanying a “negative” response, this one from a tenured computer scientist:

“From the perspective of the department, [advising center students who are not part of the department] is viewed as negative in a sense because it takes faculty away from the department.”

This and comparably negative responses seem to make sense in that these center tasks and duties do not benefit (in any obvious way) academic departments. Rather, they constitute potential time and resources taken away from departments by centers (Stahler & Tash 1994).42

**“Direct” indicators of role strain**

Many of the “at risk” center scientists report experiencing center induced role strain. None of the “low to no risk” scientists (who could not distinguish between their center and department tasks and duties) indicated experiencing center induced role strain.

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42 The 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 interviewees 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” center related behaviors. The data is therefore too inconclusive for systematic interpretation and, accordingly, is stricken from the discussion and analysis below.
Though the interviews included reports of both dimensions of role strain, reports of being overworked due to dual obligation to center and department (“inter sender” role strain) were more common than reports of center and department demands conflicting with or contradicting one another in some way (“inter role” role strain).

One junior level engineer affiliating with an ERC in addition to working in an academic department was quite calculating when discussing the work overload resulting from her center affiliation:

“If the center wants to claim 25 percent of my effort, and then I have effort on my grants, so there’s maybe 10 percent left to apply to the usual teaching… So this is going to have to change.”

Another scientist, a tenured biologist, while acknowledging that work overload is a negative aspect center affiliation, was more reserved:

“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 continued:

“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.’”

And from a microbiologist:

“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 strain (in which center and department expectations are incompatible or conflicting) constitute perhaps the more interesting data from the interviews. A junior level scientist affiliating with an STC in addition to working in a biology department reports:

“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, to use his words, “strongly persuaded” by his department chair to begin work with an ERC reports:

“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 help to reinforce the argument (from Chapter 3) that there exist fundamental differences between academic departments and university research centers, particularly in terms of organizational mission, practice, and interactive processes. Moreover, the reports help to reinforce the argument (from Chapter 4) that center scientists, at least under certain circumstances, fulfill distinct center and department roles.
Most important, however, is the story that begins to unfold regarding how university research centers can affect the workaday lives of the scientists they share with academic departments.

Affiliation with a center can cause role strain and lead university scientists to work additional hours to meet center demands and expectations on top of the hours they already work to meet department demands and expectations. Though I review the concept of center induced role strain earlier in this chapter and the general concept of role strain above (in Chapter 1), it is important to reiterate that center induced role strain is a “structural circumstance” (Merton 1957) to which center scientists may or may not be exposed. When center and department norms and expectations “match” or converge, the circumstance of center induced role strain does not exist. When center and department norms and expectations “do not match” or diverge, it does exist.

The above reports of center induced role strain, of both the inter sender and inter role dimensions, suggest exactly this. When departments are not aware of or are not concerned with their faculty members’ center related duties, when center research is not amenable to the outputs valued in departments, center induced role strain occurs and center scientists must perform “double duty” to meet the disparate expectations of both center and department. When the opposite is the case, when centers and departments communicate and coordinate regarding the expectations of the scientists they share and when center research and department research is more or less “the same,” center scientists are required to work only to meet a unified set of expectations rather than dual sets.
Center induced role strain and tenure status

It is not clear when untenured center scientists indicate experiencing “center induced role strain” if it is because of their dual affiliation to center and department or more specifically due to the interaction of their center affiliation and their junior status. Above, a junior scientist is quoted as an example of “inter role” role strain insofar as fulfillment of center expectations will not help her get started in her career. Similar, from another untenured but tenure track center scientist:

“I feel the department in general understands an assistant professor needs to be somewhat left alone to research and develop her academic career. I feel that the center does not exactly have those interests in mind. It is not so much that the center and the department directly conflict, but they seem to have my interests in mind differently. The department seems to be more focused on my career and what the department can do for me, the center seems more focused on what I can do for the center.”

While just two of the eleven junior scientists interviewed made comments like this, it reminds us that center scientists fulfill numerous roles, not just those related to centers and departments. Whether the above responses indicate the “inter role” dimension of center induced role strain or whether they indicate the “person-role” dimension of role strain, whereby an individual faces expectations that are incompatible with her values (see Chapter 1), is hard to say without additional interviews. Either way, the structural
circumstance of role strain whereby by center expectations are divergent from alternate expectations (either of the department or of the self) is “center induced.”

**Conclusion**

Incidence of center induced role strain seems contingent on the degree to which center scientists can distinguish their center tasks and duties from their department tasks and duties. When they cannot distinguish, neither center induced role strain nor increased workload seem to occur. When they can distinguish, both occur but not always. The type of research a center conducts and the ties (if any) a center makes to its scientists’ home academic departments seem to at least in part determine whether scientists who can distinguish their center from their department work experience role strain and the increased workload that results.

This is not to propose that alternate explanations emphasizing personal motivation and “increased returns” or gain (e.g., Rosen 1974, Jacobs & Winslow 2004, Corley & Gaughan 2005) do not help to explain in large part center scientists’ time allocations. A center scientist’s behavior once he or she takes on dual center and department roles 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 that centers provide in terms of funds, equipment and infrastructure, access to collaborators and research assistants, and so on (Boardman & Bozeman, forthcoming). From an untenured assistant faculty member working in an ERC:

“*Despite the tension and some of my complaints…I don’t think I would be nearly as successful without a center like this. I have access to funding*”

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*43 This relationship is explored further in the chapters that include econometric analyses comparing the impact of the extent and nature of center affiliation, center level characteristics, as well as of tenure status on the time allocations of university scientists.*
and labs... I have affiliations with researchers in this field at [other universities] and I have conversations with people at those schools through meetings and other means. It has gotten me a lot of exposure that I would not have gotten otherwise.”

Center induced role strain is but a tandem “mechanism” (Lin 1998) that helps to explain center scientists’ time allocations, especially the time they allocate to activities do not provide direct benefits but seem to be “part of the deal” which gains them access to center based research equipment and infrastructure, funds, personnel, and so on.
It logically follows from the preceding analyses to assess systematically the impact, if any, that affiliation with a university research center has on the time allocations of university scientists. I have established (in Chapter 3) that centers and departments, as organizations, can differ in systematic ways; (in Chapter 4) that center affiliated university scientists behave differently than behave non center scientists and that they can distinguish between their center and department tasks and duties; and (in Chapter 5) that center scientists can experience the “structural circumstance” of role strain (Merton 1957) as a result of these dual roles and that this strain can lead to additional work. Each of these analyses is requisite to my central task in this study of predicting and explaining the impact of variation across (and, in the chapters following this one, within) institutional designs on university scientists’ behaviors. After all, the most fundamental variation in the workaday, university based institutions to which center scientists are exposed arguably is that between the academic department and the university research center (Bozeman & Boardman 2004).

In this chapter, I use ordinary least squares (OLS) regression⁴⁴ to analyze the impact of center affiliation on the time that university scientists allocate to research, education, grants and contracts, and service and committee related activities. The data

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⁴⁴ Because the distribution of each dependent variable is fairly normal, I use OLS regression for the models, as do most other studies of time allocation in the economics and sociology literatures. However, I also ran the models using Tobit and generalized linear regression techniques. I ran Tobit regressions because for some models the dependent variable had a large amount of zeros and the technique helps to arrive at more accurate estimator magnitudes. I ran Gamma (generalized linear) regressions because the theoretical range of the dependent variables is from zero to infinity and this type of regression technique is designed for continuous dependent variables that are bounded to be greater than zero. However, the Gamma estimators, being parameterized with an inverse power metric, are not directly comparable to the OLS and Tobit estimators.
come from the 2004 RVM Program *Survey of Academic Researchers*, which I use descriptively in Chapter 4. In my analysis I control not just for center affiliation and key demographic attributes (such as tenure status, discipline, and gender), but also for the many other sources of demand for university scientists’ work time, including those related to research collaborations, grants from government and industry, students, as well as “domestic” sources of demand including whether the respondent is married and/or has children. Per my analysis above (in Chapter 5), I use role theory and in particular the concept of center induced role strain to formulate hypotheses and guide the analysis.

**Previous study of center scientists using the 2004 RVM Program Survey data**

A few studies previous have assessed already the impact of center affiliation on university scientists using the data from the 2004 *Survey*. Corley and Gaughan (2005) use the data descriptively to observe the “gender equity” effect of center affiliation insofar as male and female respondents who indicate affiliating with centers allocate, on average, the same amount of weekly work time to writing grant proposals, to conducting both funded and independent research, and to administering grants. Gaughan and Bozeman (2005) assess the “marginal contribution” of center affiliation to university scientists’ student related activities (i.e., teaching and advising), controlling (importantly) for scientists’ industry interactions. Bozeman and Gaughan (forthcoming) demonstrate that in addition to the quantity and sources of grants from which university scientists receive research support, center affiliation also increases university scientists’ “industrial involvement,” albeit marginally when compared to the impact of having research support from industry itself.
In each of these studies, the authors note that it is important to compare the behaviors of center affiliated university scientists to those of non center or “department based” scientists (Corley & Gaughan 2005, p. 376) because of the increasing prevalence of centers on university campuses (at least in the U.S.) and, related, because a substantial percentage (40 percent) of respondents to the 2004 Survey indicate affiliation with a university research center. (See Appendix for a revised version of this statistic indicating that 30 percent of respondents affiliate with centers). The analysis I present in this chapter, while not entirely new, no less constitutes a different take on the impact of center affiliation on university scientists, one that controls for the many competing demands for university scientists’ work time.

This chapter differs from these earlier studies in theory and method. The theoretical disposition of this chapter is quite different from those of its predecessors. Though they do not state so explicitly, Corley and Gaughan (2005) indicate a “scientific and technical human capital” theoretical bent (see Bozeman et al. 2001) in their expectation that center affiliated university scientists will allocate more time to grants work and to the conduct of grants funded research due to the “greater opportunities for research” that center affiliation affords its scientists (p. 373). This bent is also reflected in the authors’ finding that center affiliation reduces if not eliminates gender based research disadvantages. Similar to Corley and Gaughan (2005), Bozeman’s forthcoming study of the relationship between having industry grants and interaction with industry exudes scientific and technical human capital thinking, particularly per the author’s argument that industry grants are better explained as a predictor (rather than as a component) of university scientists’ respective levels of industrial involvement.
I use role theory and in particular the concept of center induced role strain (see Chapter 5) to guide my analysis of the impact of center affiliation on university scientists’ time allocations to their many academic tasks and responsibilities. I delineate the inter sender dimension or “structural circumstance” (Merton 1957) of center induced role strain wherein the center scientist is subjected to increased work due to her dual obligation to fulfill equally or at least comparably legitimate expectations of both center and department (MacKinnon 1978) from the inter role dimension or circumstance wherein the center scientist is subjected to functionally and/or substantively distinct and even conflicting expectations due to the same dual obligation.

These concepts are suited to analysis of the impact of variation across and within institutional designs on university scientists’ time allocations insofar as center affiliated scientists, in affiliating with centers, expose themselves to competing sources of expectations (i.e., those from centers and those from departments, among other sources), which can in turn generate additional workload. Though it is not my intention to discount the analytic power of the scientific and technical human capital approach or of other approaches emphasizing “increased returns” or gain (e.g., Rosen 1974, Jacobs & Winslow 2004, Corley & Gaughan 2005), which are undeniably suited for explaining behaviors that perhaps are the result of the enhanced opportunities afforded by affiliating with a center, no less the concept of center induced role strain seems well suited for explaining those behaviors of university scientists that are not necessarily the direct result of enhanced opportunities (such as time allocations to non research, administrative activities) but may well be the result of the “structural circumstance” (Merton 1957) of
distinct and even competing demands and expectations that accompanies fulfilling two workplace roles simultaneously.45

Model specification

Above (in Chapter 5), I use data from interviews with center affiliated university scientists to suggest that when center and department norms and expectations regarding the workaday behaviors of the scientists they share diverge or conflict, center scientists work more than they work when center and department norms and expectations are closely related or even identical. Accordingly, in the model specification for this chapter I include numerous explanatory variables representing (potential) other sources of role strain (i.e., role strain that is not center induced) to which university scientists may be exposed insofar as each variable poses (again, potentially) an additional source of expectations and therefore demand for university scientists’ work time.

Explanatory variables

The definition of “university research center” provided in the 2004 Survey reads “A university research center is a ‘research institution that has five or more faculty and

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45 It is important to note that neither approach is inconsistent with economic models of human capital investment positing that time is allocated across various alternatives based on relative expected returns (e.g., Rosen 1974, Singell et al. 1994). This is perhaps more apparent for scientific and technical human capital theory than it is for role theory. I use the concept of role strain to hypothesize, for instance, that center affiliated university scientists allocate more time to research than allocate non center scientists, as do others using more explicitly “motivational” approaches (e.g., Gaughan & Corley 2005, Singell et al. 1994). Though role theory is admittedly “weak” on motivation (Biddle 1979, p. 345), emphasizing the expectations of centers and departments rather than the focal scientist’s motivation to increase her returns (Singell et al. 1994) or to capitalize on “enhanced opportunities” (Corley & Gaughan 2005), the role approach is not inconsistent with motivational notions insofar as it posits role fulfillment (e.g., the conduct of research) in situations wherein the role sender (e.g., the center or the department) is viewed by the role recipient (e.g., the center affiliated scientist) as legitimate or as wielding sanctioning power (Biddle 1979). While center affiliated university scientists may view departments as legitimate because of their sanctioning power (i.e., the granting or denial of pay, promotion, access to resources), they view centers as legitimate because of the benefits they afford their member scientists, including access to equipment and infrastructure, to collaborators both within and outside the university, and so on. The advantage of role theory versus human capital based approaches is that in addition to accommodating scenarios wherein motivation and increased returns are factors it too can account for scenarios wherein motives and returns are not so apparent. I discuss this further, below, when explaining this chapter’s hypotheses.
postdoctoral researchers and includes participants from more than one discipline and more than one academic department.

46 This broad definition has yielded a center affiliation rate of 30 percent (see Appendix).

The explanatory variables with which I operationalize respondents’ center affiliation indicate in different ways in which center affiliated university scientists may be beholden to their respective centers.

CENTTIME – A continuous variable indicating the percentage of research related work time the respondent allocates to center related work.

CENTSAL – A continuous variable indicating the percentage of respondent salary paid by the center, including any salary from center based grants and contracts.

I use these variables instead of a binary indicator of center affiliation because some (but not all) of the interview data above (in Chapter 5) suggest that center demands and expectations are not always viewed by center scientists to be as important or as “legitimate” (Biddle 1979) as department demands and expectations, for instance in the case of some junior scientists. Controlling for the percentage of research time and salary that are center related perhaps account better for the extent to which center scientists may (or may not) feel obligated to fulfill their respective center roles in addition to their

---

46 Compare the 2004 Survey definition to those reviewed in Chapter 2. Zajkowski (2003) emphasizes relations with external funding bodies; Bozeman & Boardman (2003) emphasize separateness from academic departments as well as the inclusion of scientists from more than one department; Gray and colleagues (2001) similarly emphasize independence from departments and multidisciplinary research teams, as well as access to equipment and facilities; Geiger (1990) emphasizes external support, that center scientists are rooted primarily in academic departments, and the problem focus (versus discipline focus) of center research. The 2004 Survey definition addresses the inclusion of scientists from multiple departments and disciplines but does not address research focus, separateness from academic departments, or funding sources.
department roles. Moreover, to the extent that exposure to center demands and expectations is indicated when at least one of these measures has a value greater than zero, they may also be considered as “objective” indicators of the inter sender dimension of center induced role strain (see Chapter 1) insofar as they represent norms and expectations that constitute components of the work environments of center scientists that are not a part of the work environments of non center scientists.

Extant study (e.g., Milem et al. 2000, Singell et al. 2002) suggests many other potential sources of work place demand for the work time of university scientists, center affiliated or not.

GOVGRANTS – A count variable indicating the total number of active government grants supporting respondent research.

INDGRANTS – A count variable indicating the number of active industry grants supporting respondent research.

TOTSTUD – A count variable indicating the total number of students that a respondent supports with research grants from any source. The count includes undergraduate, masters, and doctoral students.

TOTCOL – A count variable indicating the total number of researchers, either faculty or graduate students, with which a respondent collaborates.

The more grants has a university scientist, the more time she is likely to spend conducting research and working in general (Singell et al. 2002, Bozeman, forthcoming). Students and collaborators similarly may increase the amount of time scientists spend working.

The general rationale here is “additional work place obligations equal additional work.”

47 I actually ran all of the models both ways, the first including the binary variable and the second including the percentage variables. The models do not differ across their specifications in direction or statistical significance.
Non work place sources of demand for faculty time, such as demand from domestic sources, too may affect the amount of time that university scientists allocate to their academic tasks and responsibilities.

MARRIED – A binary variable coded “1” if the respondent indicates being married, zero otherwise.

CHILD – A count variable indicating the quantity of children has a respondent.

The rationale here is the opposite wherein non work place demands may see a decrease in the amount of time that university scientists spend working.

Other factors, while they do not constitute per se expectations of university scientists (and therefore do not constitute demands for their work time and effort), certainly can affect how university scientists allocate their time across their workaday tasks and responsibilities.

MALE – A binary variable coded “1” if the respondent is male, zero female.

TENURE – A binary variable coded “1” if the respondent has received tenure, zero if untenured but tenure track.

Male faculty have been shown to work more than female faculty in general and, further, attributes such as being married and having children have been shown to decrease hours worked per week more for female faculty than for male faculty (Jacobs & Winslow 2004). Tenure has been shown to decrease total hours worked (Jacobs & Winslow 2004). Moreover (and more interesting), the above interview data (see Chapter 5) include two reports of untenured but tenure track center scientists shirking the fulfillment of center
expectations to fulfill department expectations because the latter will help them “get
started” in their careers.

There also may be discipline or field effects.

CS – A binary variable coded “1” if the respondent is a computer scientist
of one ilk or another, zero otherwise.

PHYS – A binary variable coded “1” if the respondent is a physicist of one
ilk or another, zero otherwise.

AG – A binary variable coded “1” if the respondent is an agricultural
scientist of one ilk or another, zero otherwise.

ENG – A binary variable coded “1” if the respondent is an engineer of one
ilk or another, zero otherwise.

Biologists constitute the reference discipline.

To determine the extent to which (if at all) affiliation with a university research
center affects how university scientists allocate their work time across their academic
tasks and duties, I specify the following model:

$$\beta_0 + \beta_1 \% \text{TIME ON CENTER WORK} + \beta_2 \% \text{SALARY FROM CENTER} + $$
$$\beta_3 \text{GOVT GRANTS} + \beta_4 \text{INDUSTRY GRANTS} + \beta_5 \text{QTY STUDENTS} + $$
$$\beta_6 \text{QTY COLLABORATE} + \beta_7 \text{MARRIED} + \beta_8 \text{CHILDREN} + $$
$$\beta_{9,12} \text{DISCIPLINE} + \beta_{13} \text{TENURE} + \beta_{14} \text{MALE} + E$$

Where $\beta_{9,12} \text{DISCIPLINE}$ is a vector comprised of the discipline binary variables listed
above and $E$ is the error term.\(^{48}\)

\(^{48}\) The reference group for the model is therefore female biologists who have no industry or government
grants, no students funded by grants, are not married, have no children, are not tenured but are on the tenure
track, and who do not allocate any of their research time to university research center work or receive any
part of their salary from a center.
**Dependent variables**

I use hour allocations for the dependent variables. The 2004 *Survey* item from which this data derives asks respondents to indicate for “the most recent full academic term” the average number of hours per week they allocated to writing proposals, conducting research, teaching, administering grants and contracts, performing service and committee duty, advising students, and consulting. From this data I calculate six variables for measuring the composition of university scientists’ academic work.

- Total hours per average work week allocated to academic tasks and duties
- Total hours spent on research
- Total hours spent on grants and contracts work
- Total hours spent on university service
- Total hours spent teaching
- Total hours spent advising students

(See Appendix for the full survey.)

**Hypotheses**

To form hypotheses regarding the impact of center affiliation on university scientists’ workaday time allocations, I rely on my above analysis (in Chapters 4 and 5), which emphasizes the concept of center induced role strain as well as on previous study of university scientists’ time allocations that use different theories (e.g., Singell *et al.* 1994, Milem *et al.* 2000, Corley & Gaughan 2005, Gaughan & Bozeman 2005).

The first hypotheses are the most fundamental.
H1. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked per week on academic tasks and duties increases, all else equal.

This hypothesis may be explained by a number of extant findings and theories, none of which is clearly superior to the others. Milem and colleagues (2000) demonstrate that institutional type can increase the amount of time that faculty devote to research. Corley and Gaughan (2005) imply a scientific and technical human capital approach in their explanation of why center affiliated university scientists conduct more research than conduct their non center counterparts, emphasizing the enhanced research opportunities afforded by centers. Stahler and Tash (1994) suggest that center scientists conduct more research simply because research constitutes the primary practice of university research centers. Because research and its outputs are emphasized in departmental tenure and promotion decisions (Braxton & Del Favero 2002), moreover, increased research time spent on center related work may increase the time university scientists allocate to research in total due to the “returns” they receive by “investing” their time in this way (Rosen 1974, Shapiro 1978).

The inter sender dimension of role strain (Kahn et al. 1964), addressed in Chapters 1 and 5, too can explain why time spent on center research may increase university scientists’ total hours worked. To the extent that exposure to center demands and expectations is indicated when the percentage of research time allocated to center research has a value greater than zero, a scientist experiences the “structural circumstance” (Merton 1957) of inter sender role strain whereby she is exposed to not only department demands and expectations but also to center demands and expectations.
Fulfillment of dual center and department demands and expectations will see an increase in the number of tasks the scientist must perform and therefore an increase in the hours worked (MacKinnon 1978) when compared to scientists beholden to fulfill only department demands and expectations.49, 50

The percentage of research time that a university scientist devotes to center based work, moreover, seems a valid proxy for how “legitimate” a scientist perceives center based expectations and demands to be, which can determine whether an individual allocates time and energy to meet role expectations (Biddle 1979). While emphasis on inter sender role strain and the perceived legitimacy of center demands and expectations may seem somewhat tortured when compared to alternate explanations emphasizing increased returns rather than role strain, I use role theory because it is supported by the interview data presented in Chapter 5 and, moreover, because it seems better suited for explaining the behaviors that centers expect of their scientists that do not constitute enhanced opportunity or increased returns per se (see below) but may well be the result of exposure to dual workplace demands and expectations.51

No matter the explanation one prefers, center based research seems not a substitute for department work, but instead an additional research obligation. However, this may cease to be (entirely) the case if the center pays a proportion of the center scientist’s salary.

49 Comparable concepts from role theory that similarly predict increased workload resulting from role strain include “role malintegration” wherein a “social system” contains several competing sources of authority and “role set complexity” wherein the focal individual’s “role set” (i.e., all of the roles that the individual is expected to fulfill) consists of roles that are only “partially differentiated” (Biddle 1979, p. 76-77).

50 In the data there are no instances in which a scientist indicated affiliation with a university research center but also indicated spending zero percent of her research time on center related research.

51 Moreover, the idea of strain due to increased workload is well suited for explaining the effects of institutional variation across centers, which constitute “objective” measures of the inter role dimension of role strain (see Chapter 1), on university scientists’ time allocations (see Chapter 8).
H2. As the percentage of a center scientist’s salary that is paid by the university research center increases, that scientist’s total hours worked per week on academic tasks and duties decreases, all else equal.

One seeming problem here is that the proportion of salary paid by a center may increase how “legitimate” the center affiliated scientist perceives center based expectations and demands to be and therefore may increase (rather than decrease) total time worked. However, when a center and department coordinate in this way (on salary), it is suggestive of a scenario in which centers and departments coordinate regarding the expectations and demands of the scientists they share. Such coordination may mitigate center induced role strain by bringing into closer alignment the demands and expectations that each academic unit holds for these scientists and thereby decrease their respective workloads (MacKinnon 1978). Unlike the expected effect of an increase in the percentage of research time a scientist allocates to center research, when a center pays part of a scientist’s salary the effect may be substitutive rather than additive.

The rationale for Hypothesis 1 applies to Hypotheses 3.

H3. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked per week on research increases, all else equal.

As with total work time, there is no clear determination of whether potential returns or center induced role strain best explain why center scientists may allocate more time per week to research than allocate non center scientists. As discussed above, the two interpretations need not be mutually exclusive.

The rationale for Hypothesis 2 applies to Hypothesis 4.
H4. As the percentage of a center scientist’s salary that is paid by the university research center increases, that scientist’s total hours worked per week on research decreases, all else equal.

The expected effect of an increase in the proportion of a center scientist’s salary paid for by a center is the same for (the remaining activities for which I have data of) grants and contracts work, teaching, university service, and student advising. In each instance, expected is a substitution not an additive effect whereby the time allocated to the activity decreases. A proportion of “salary sharing” between a center and department is suggestive of a scenario in which centers and departments coordinate regarding the expectations and demands of the scientists they share. Therefore the “structural circumstance” (Merton 1957) of the inter sender dimension of role strain is mitigated, as described above for Hypothesis 2. Because of their similarity, I do not present further “salary sharing” hypotheses below. I do, however, present subsequent hypotheses regarding the impact of the percentage of research time spent on center based work insofar as the “mechanism” (Lin 1998) is different somewhat for non research activities than for research and for total academic work time.

The inter sender dimension of role strain perhaps better explains than the alternate approaches (emphasizing increased returns or gain rather than strain) the time that center scientists allocate to activities that may not be viewed by center scientists as enhanced opportunity per se but rather as “part of the deal” of center affiliation.

H5. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked per week on grants and contracts work increases, all else equal.
H6. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked per week on university based service and committee work increases, all else equal.

Corley and Gaughan (2005) suggest that center scientists allocate more time to these tasks because of the enhanced opportunities for research afforded by university research centers. If center affiliation offers enhanced opportunities for research and thereby increases the amount of time that university scientists allocate to the conduct of research, so too, it seems, must these scientists spend increased work time on those tasks and duties necessary to procure or maintain research funding.

Though the idea of center affiliation enhancing opportunities for research is certainly valid, it seems less likely that any university scientist would consider the attendant administration and service work as an additional opportunity per se. More likely is the center affiliated university scientist accepting such administrative and service duties as “part of the deal” which gains them access to center based research equipment and infrastructure, funds, personnel, and so on. That many of the center scientists I interviewed could distinguish their center based grants from their department based grants and, moreover, that many of these same scientists reported experiencing center induced role strain wherein center expectations regarding grants administration work constituted “extra work” rather than “enhanced opportunity,” supports this rationale (see Chapter 5).

Up until now the hypotheses have related to university scientists’ time allocations to activities that are expected of university scientists by both university research centers and academic departments. Accordingly, hypotheses for the impact of the percentage of
research time a center scientist spends on center research have been positive per the “double duty” that center affiliation constitutes with respect to these activities (Bozeman & Boardman 2003, p. 29). The next hypotheses address the impact of center affiliation on the time scientists allocate to the (generally) department based practices of teaching and student advising (see Chapter 3).

H7. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked spent teaching decreases, all else equal.

H8. As the percentage of research time that a university scientist allocates to center related work increases, that scientist’s total hours worked spent advising students decreases, all else equal.

Unlike for research and research related activities, and contrary to what a moderate proportion of extant study52 suggests, these hypotheses are negative. Exposure

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52 If one considers that centers expect of their scientists first and foremost the conduct of research (Stahler & Tash 1994), then there are numerous studies assessing the relationship between teaching and research to consider here. However, the findings from this literature are mixed and provide little guidance. Shapiro (1978) and Massy and Zemsky (1994) suggest a tradeoff between time allocated to research and teaching while others (e.g., Braxton 1996, Milem et al. 2002) suggest a reinforcing relationship. Still others (e.g., Feldman 1987) argue that research and teaching are unrelated in terms of relative time allocations. If one considers the logic of inter-sender role strain, then the hypothesis regarding teaching (and, below, those regarding student advising) would be “no effect” (instead of negative) insofar as these activities are predominantly department based (see Chapter 3) and departments are perceived by center affiliated scientists to be as “legitimate” as centers in terms of demands for their work time, if not more so given that most center affiliated scientists have primary appointments in academic departments. Because centers do not typically expect of their respective member scientists the practice of center based teaching, the amount of time allocated to teaching should not increase. If centers expected of their scientists this practice, the hypothesis would be positive as are the hypotheses for research, grants and contracts work, and service and committee duties. The logic of “inter role” role strain perhaps is more appropriate insofar as it acknowledges that distinct expectations may be so not only in source (i.e., from center and/or from department) but also in substance (i.e., teaching versus research) (Kahn et al. 1964, Biddle 1979). Inter role role strain, while it has been shown to decrease role performance in family versus work settings (Chiu 1998), has been shown to increase work performance in formal organizational settings (MacKinnon 1978). Role recipients, center affiliated university scientists, who are subjected to functionally and/or substantively distinct roles feel obligated to work additional time to perform each of the incompatible activities because the recipient perceives both role senders, the center and department, as constituting legitimate demands for their time and energy. Per this logic, as with that for inter sender role strain above, hypotheses regarding the
to center demands and expectations in tandem with exposure to department demands and expectations (as indicated when the percentage of research time allocated to center work is greater than zero) is suggestive of the “structural circumstance” (Merton 1957) of the inter sender dimension of role strain. Because the behaviors of teaching and student advising are generally expected by departments but not by centers (see Chapter 3), it seems likely that center induced role strain may take time and energy away from “department only” activities like teaching. My interviews with center affiliated scientists suggest such a tradeoff between center activities and departmental teaching and advising. Though in many instances there were no reports of centers “buying out” the teaching requirements of their department based scientists, no less many reported having less time for teaching and student related activities due to the dual obligation to center and department.53

Results

For illustrative purposes, for each of the hypotheses I present the results for two versions of the model specification. In the limited version, the only demand or expectation for faculty time that I control for is the proportion of research time allocated to center based work and the attendant center salary variable. In practically all of these models, the percentage of time spent on center based research is statistically significant in the direction hypothesized. In the full version, I include controls for all demands and

impact of center affiliation on time allocated to teaching and student advising again should be “no effect,” because departments but not centers expect their scientists to teach classes.

53 However, I remain tentative that there will be any effect at all of percentage of research time spent on center work on the hours allocated to teaching and student advising. The role theoretic logic employed above suggests that distinct expectations and demands for one’s work time has an additive effect. Because teaching and student advising are predominantly activities expected by departments and not centers, for this additive effect to hold (at least for the model predicting total time allocated to academic tasks and duties), the amount of time that center scientists spend teaching and advising students would have to remain constant.
expectations for faculty time that the 2004 *Survey* data allow, including quantity of industry grants, quantity of government grants, quantity of students funded, and quantity of research collaborators. In many (though certainly not all) of these models, quantity of grants and quantity of students sap the center related measures of statistical significance.

Of the center related statistically significant results, the percentage of research time a scientist spends on center based work affects the hours per week that university scientists allocate to grants and contract work, university based service, and teaching. Center affiliation does not affect the total time each week that university scientists spend on academic work in total nor does it affect hours per week that they allocate to research. The proportion of center scientists’ salaries paid by centers is statistically significant for teaching and student advising. I reserve discussion for the final section of this chapter.54

**Total academic work time**

Regression analysis fails to support Hypotheses 1 and 2. While the proportion of time allocated to center based research (CENTTIME) is statistically significant in the direction hypothesized in the limited model, neither it nor the proportion of respondents’ salaries paid for by centers (CENTSAL) affect expected total work time in the full model.

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54 In this chapter I present the results using OLS regressions for the models. The Appendix contains these results in addition to those for Tobit and Gamma regressions. From the OLS to the Tobit results, there were no changes in the statistical significance or directions of the estimators. There were slight changes in the magnitudes of the estimators from OLS to Tobit, with the Tobit estimators being slightly larger in magnitude. There were no changes in relative magnitude from the OLS to the Tobit estimators. For instance, in the model for hours per week allocated to research, the estimator for CTR_COLLEGE is smaller than that for CTR_STDALN, which is smaller than the estimator for CTR_OFFCAMP. From the OLS to the Gamma results, there were no changes in the statistical significance or directions of the estimators (keeping in mind that because the Gamma regression is parameterized using an inverse power metric, the signs should be reverse). There also were no changes in the relative magnitudes of the estimators.
Table 8. Regression results for total academic work time (Hypotheses 1 and 2)

<table>
<thead>
<tr>
<th>HOURS PER WEEK WORKED ON ACADEMIC TASKS</th>
<th>Limited</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTTIME</td>
<td>0.046*</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>-0.055</td>
<td>-0.044</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>INDGRANTS</td>
<td>3.799**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.479)</td>
<td></td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td>0.319</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.490)</td>
<td></td>
</tr>
<tr>
<td>TOTSTUD</td>
<td>0.432***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.153)</td>
<td></td>
</tr>
<tr>
<td>TOTCOL</td>
<td>-0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td></td>
</tr>
<tr>
<td>ENGR</td>
<td>-1.467</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.545)</td>
<td></td>
</tr>
<tr>
<td>AG</td>
<td>-6.225***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.892)</td>
<td></td>
</tr>
<tr>
<td>PHYS</td>
<td>0.079</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.531)</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>1.489</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.863)</td>
<td></td>
</tr>
<tr>
<td>TENURED</td>
<td>-2.547**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.048)</td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>-0.267</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.069)</td>
<td></td>
</tr>
<tr>
<td>MARRIED</td>
<td>-1.876</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.297)</td>
<td></td>
</tr>
<tr>
<td>CHILD</td>
<td>-0.193</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.443)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>48.885***</td>
<td>51.866***</td>
</tr>
<tr>
<td></td>
<td>(0.563)</td>
<td>(1.898)</td>
</tr>
<tr>
<td>Observations</td>
<td>1637</td>
<td>1590</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.00</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Of the alternate “work time demand” variables, quantity of students funded by grants (TOTSTUD) and quantity of industry grants (INDGRANTS) are statistically significant. Each additional industry grant increases the time that a university scientist is expected to work per week by nearly four (3.8) hours, ceteris paribus. Each additional student that a university scientist funds with grant monies increases the time that the scientist is expected to work per week by approximately twenty five minutes (.43 * 60), ceteris
paribus. Other statistically significant effects include having tenure (TENURED) and working in the agricultural sciences (AG).

However, center affiliation may no less “matter” insofar as it is an important predictor of each of the statistically significant alternate “work time demand” variables (see Appendix). Accordingly, quantity of students funded by grants and quantity of grants may comprise part of the “mechanism” (Lin 1998) via which university research centers affect university scientists’ time allocations, particularly regarding the conduct of research (see below). But this reasoning does not circumvent the lack of statistically significant results regarding the impact of center affiliation.

Time allocated to research

Regression analysis fails to support Hypotheses 3 and 4. Neither the proportion of time allocated to center based research (CENTTIME) or the proportion of respondents’ salaries paid for by centers (CENTSAL) are statistically significant for the limited or full model specification.

Table 9. Regression results for research (Hypotheses 3 and 4)

<table>
<thead>
<tr>
<th></th>
<th>HOURS PER WEEK ALLOCATED TO RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited</td>
</tr>
<tr>
<td>CENTTIME</td>
<td>0.025 (0.016)</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>-0.036 (0.023)</td>
</tr>
<tr>
<td>INDGRANTS</td>
<td></td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td></td>
</tr>
<tr>
<td>TOTSTUD</td>
<td></td>
</tr>
<tr>
<td>TOTCOL</td>
<td></td>
</tr>
<tr>
<td>ENG</td>
<td></td>
</tr>
<tr>
<td>AG</td>
<td></td>
</tr>
</tbody>
</table>
As with the previous model, many of the alternate “work time demand” variables are statistically significant. Quantity of students funded by grants (TOTSTUD), quantity of industry grants (INDGRANTS), and quantity of government grants (GOVGRANTS) are all positive and statistically significant. Quantity of research collaborators (TOTCOL) is significant but negative, suggesting that the more human resources a scientist brings to her research in a collaborative capacity may help to decrease workload slightly. Three of the four are statistically significant at the one percent level. Other statistically significant effects include having tenure (TENURED) and being male (MALE), which decreases and increases the amount of research, respectively.

**Time allocated to grants and contracts work (not research)**

Regression analysis supports Hypothesis 5. The proportion of time allocated to center based research (CENTTIME) is statistically significant in the direction hypothesized in the full model predicting the expected work time per week allocated to grants and contracts work. For each percentage point increase in the research time that a center scientist allocates to center based work, the time that the same scientist is expected
to work on grants and contracts work increases by about a minute \((.018 \times 60 = 1.08\) minutes), ceteris paribus.\(^55\)

Table 10. Regression results for grants and contracts work (Hypotheses 5)

<table>
<thead>
<tr>
<th>HOURS PER WEEK ALLOCATED TO GRANTS AND CONTRACTS WORK</th>
<th>Limited</th>
<th>Full</th>
</tr>
</thead>
</table>
| CENTTIME                                             | 0.035***  
\((0.010)\)  | 0.018*  
\((0.010)\) |
| CENTSAL                                             | 0.025  
\((0.019)\) | 0.026  
\((0.018)\) |
| INDRGRANTS                                           | 0.281  
\((0.376)\) | |
| GOVGRANTS                                            | 0.788***  
\((0.227)\) | |
| TOTSTUD                                              | 0.296***  
\((0.068)\) | |
| TOTCOL                                               | 0.004***  
\((0.001)\) | |
| ENG                                                  | -0.525  
\((0.684)\) | |
| AG                                                   | 0.335  
\((0.879)\) | |
| PHYS                                                 | -1.737**  
\((0.675)\) | |
| CS                                                   | -2.431***  
\((0.804)\) | |
| TENURED                                              | -1.782***  
\((0.401)\) | |
| MALE                                                 | -0.782**  
\((0.335)\) | |
| MARRIED                                              | -0.967*  
\((0.554)\) | |
| CHILD                                                | 0.067  
\((0.157)\) | |
| Constant                                             | 7.157***  
\((0.179)\) | 8.673***  
\((0.819)\) |
| Observations                                         | 1639    | 1592  |
| R-squared                                            | 0.02    | 0.12  |

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Many of the alternate “work time demand” variables are statistically significant and positive, including quantity of students funded by grants (TOTSTUD), quantity of

\(^55\) The mean value for CENTTIME in the 2004 Survey data set is 8.55 and the standard deviation is 21.7, indicating much variation (see Appendix).
government grants (GOVGRANTS), and quantity of research collaborators (TOTCOL). Being male, having tenure, and being married decrease the expected time allocated to grants and contract work, ceteris paribus.

**Time allocated to service and committee work**

Regression analysis supports Hypothesis 6. The proportion of time allocated to center based research (CENTTIME) is statistically significant in the direction hypothesized in the full model predicting the expected work time per week allocated to university based service and committee work. In fact, the expected effect is identical as that for grants and contracts work. For each percentage point increase in the research time that a center scientist allocates to center based work, the time that the same scientist is expected to work on university based service and committee work increases by about a minute (.018 * 60 = 1.08 minutes), ceteris paribus.

Table 11. Regression results for university service and committee work (Hypothesis 6)

<table>
<thead>
<tr>
<th></th>
<th>HOURS PER WEEK ALLOCATED TO UNIVERSITY, DEPARTMENTAL, OR RESEARCH CENTER SERVICE AND COMMITTEE WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited</td>
</tr>
<tr>
<td>CENTTIME</td>
<td>0.022**</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
</tr>
<tr>
<td>INDGRANTS</td>
<td>0.735*</td>
</tr>
<tr>
<td></td>
<td>(0.429)</td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td>-0.064</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
</tr>
<tr>
<td>TOTSTUD</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
</tr>
<tr>
<td>TOTCOL</td>
<td>-0.549</td>
</tr>
<tr>
<td></td>
<td>(0.659)</td>
</tr>
<tr>
<td>ENG</td>
<td>-0.930</td>
</tr>
<tr>
<td></td>
<td>(0.650)</td>
</tr>
<tr>
<td>AG</td>
<td>-1.496*</td>
</tr>
<tr>
<td></td>
<td>(0.770)</td>
</tr>
<tr>
<td>PHYS</td>
<td>-0.549</td>
</tr>
<tr>
<td></td>
<td>(0.659)</td>
</tr>
<tr>
<td>CS</td>
<td>-0.587</td>
</tr>
<tr>
<td></td>
<td>(0.870)</td>
</tr>
<tr>
<td></td>
<td>Coefficient</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>TENURED</td>
<td>3.302**</td>
</tr>
<tr>
<td>MALE</td>
<td>-0.665**</td>
</tr>
<tr>
<td>MARRIED</td>
<td>0.586</td>
</tr>
<tr>
<td>CHILD</td>
<td>-0.027</td>
</tr>
<tr>
<td>Constant</td>
<td>4.999***</td>
</tr>
<tr>
<td>Observations</td>
<td>1639</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

For the first time many of the alternate “work time demand” variables are not statistically significant. Quantity of industry grants is significant and positive. Notable is the relatively modest decrease in the magnitude of the estimator for CENTTIME from the limited model to the full model.

**Time allocated to teaching**

Regression analysis supports Hypothesis 7. The proportion of time allocated to center based research (CENTTIME) is statistically significant in the direction hypothesized in the full model predicting the expected work time per week allocated to teaching. For each percentage point increase in the research time that a center scientist allocates to center based research, the time that the same scientist is expected to teach decreases by about two minutes (.033 * 60 = 1.98 minutes), ceteris paribus. The proportion of a respondent’s salary that is paid for by a center (CENTSAL) too is statistically significant and negative. Each additional percentage point of a respondent’s salary that is paid by a center decreases the expected time per week that a university scientist allocates to teaching by about the same margin as does CENTTIME, ceteris paribus.
Table 12. Regression results for teaching (Hypothesis 7)

<table>
<thead>
<tr>
<th></th>
<th>HOURS PER WEEK ALLOCATED TO TEACHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited</td>
</tr>
<tr>
<td>CENTTIME</td>
<td>-0.038*** (0.011)</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>-0.035 (0.021)</td>
</tr>
<tr>
<td>INDRGRANTS</td>
<td>0.170 (0.504)</td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td></td>
</tr>
<tr>
<td>TOTSTUD</td>
<td></td>
</tr>
<tr>
<td>TOTCOL</td>
<td></td>
</tr>
<tr>
<td>ENG</td>
<td>1.160 (1.117)</td>
</tr>
<tr>
<td>AG</td>
<td></td>
</tr>
<tr>
<td>PHYS</td>
<td>0.671 (1.126)</td>
</tr>
<tr>
<td>CS</td>
<td>0.765 (1.277)</td>
</tr>
<tr>
<td>TENURED</td>
<td>-0.717 (0.601)</td>
</tr>
<tr>
<td>MALE</td>
<td>-0.911* (0.478)</td>
</tr>
<tr>
<td>MARRIED</td>
<td>-0.753 (0.764)</td>
</tr>
<tr>
<td>CHILD</td>
<td>-0.157 (0.208)</td>
</tr>
<tr>
<td>Constant</td>
<td>16.424*** (0.264)</td>
</tr>
<tr>
<td>Observations</td>
<td>1638</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Of the alternate “work time demand” variables, quantity of government grants has a statistically significant and negative impact, as does number of research collaborators, working in the agricultural sciences, and being male.

**Time allocated to student advising**

Regression analysis fails to support Hypothesis 8. The proportion of time allocated to center based research (CENTTIME) is not statistically significant in the limited model predicting expected time per week allocated to student advising, nor is it
significant in the full model. However, the proportion of a respondent’s salary that is paid for by a center (CENTSAL) is statistically significant and negative. Each additional percentage point of a respondent’s salary that is paid by a center decreases slightly the expected time per week that a university scientist allocates to student advising, ceteris paribus.

Table 13. Regression results for student advising (Hypothesis 8)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Limited</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTTIME</td>
<td>0.005</td>
<td>0.004</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>-0.011*</td>
<td>-0.011**</td>
</tr>
<tr>
<td>INDGRANTS</td>
<td>0.108</td>
<td>0.230</td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td>-0.184*</td>
<td>(0.112)</td>
</tr>
<tr>
<td>TOTSTUD</td>
<td>0.049*</td>
<td>(0.029)</td>
</tr>
<tr>
<td>TOTCOL</td>
<td>-0.001</td>
<td>(0.000)</td>
</tr>
<tr>
<td>ENG</td>
<td>0.327</td>
<td>(0.250)</td>
</tr>
<tr>
<td>AG</td>
<td>0.666*</td>
<td>(0.367)</td>
</tr>
<tr>
<td>PHYS</td>
<td>0.094</td>
<td>(0.258)</td>
</tr>
<tr>
<td>CS</td>
<td>0.729*</td>
<td>(0.382)</td>
</tr>
<tr>
<td>TENURED</td>
<td>0.311*</td>
<td>(0.162)</td>
</tr>
<tr>
<td>MALE</td>
<td>-0.297*</td>
<td>(0.151)</td>
</tr>
<tr>
<td>MARRIED</td>
<td>-0.273</td>
<td>(0.241)</td>
</tr>
<tr>
<td>CHILD</td>
<td>0.157**</td>
<td>(0.071)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.457***</td>
<td>2.226***</td>
</tr>
<tr>
<td>Observations</td>
<td>1638</td>
<td>1591</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.00</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Of the alternate “work time demand” variables, only quantity of government grants and students funded by grants have statistically significant impacts.
Discussion

The purpose of this chapter has not been to designate center affiliation as a primary predictor of university scientists’ expected time allocations, but rather to make the case that university research centers, in addition to numerous other factors, can and do alter how scientists allocate their time and energy across their numerous academic tasks and duties. Controlling for as many demands on faculty for their time and energy as the 2004 Survey data allow, center affiliation demonstrates to increase the expected weekly work time that university scientists allocate to grants and contracts work and to university based service including department and center based service and committee work. The results also indicate a negative impact on expected weekly work time allocated to teaching. Suggestive of centers “buying out” the time of department based scientists is the negative impact of the proportion of a scientist’s salary paid by a center on the hours allocated to teaching and student advising.

Surprising are some of the non findings. Center affiliation does not affect the total hours worked per week by university scientists. Nor does it affect time devoted to the conduct of research. These results surprise insofar as university research centers constitute first and foremost additional research obligations for university scientists (with primary appointments in academic departments) which (generally) expect the conduct of “different” research than that expected by departments (see Chapter 3).

However, certainly not all university research centers require the conduct of research that is substantially different than that required by academic departments. Centers in fact can be very similar to departments when they focus on fundamental research that is far from market or when they focus on publishing results in refereed
media rather than on solving problems for industry or society. Moreover, some (but certainly not a majority) of the interviews with center scientists (above in Chapter 5) demonstrate that center research indeed can “count” in departmental tenure and promotion decisions, albeit usually at a discount. The fact is that university research centers vary greatly across numerous attributes (Stahler & Tash 1994), perhaps because of the relative brevity of the history of this institutional form. Accordingly, norms and expectations vary greatly across university research centers, and this variation can affect differently the behaviors of center scientists. Center norms and expectations may be quite different than or quite similar to the norms and expectations of the academic departments to which center scientists are also beholden, and therefore center norms and expectations may be more or less conducive to the “structural circumstance” (Merton 1957) of center induced role strain, respectively.

The findings in this chapter are “mixed” not because of the inadequacy of role theory for predicting university scientists’ time allocations, but because the controls for center affiliation in the above models mask heterogeneity across university research centers that can affect whether university scientists experience center induced role strain as a result of center affiliation and, in turn, that can affect the composition of their academic work. Required is systematic study of variation across university research centers and the impacts that this variation has on the behaviors of center affiliated scientists. Measurement of this variation constitutes further “objective” evidence (Rizzo et al. 1970), of center induced role strain insofar as some center level characteristics, for instance when a center has formal ties with industry partners, are observable components of center scientists’ work environments (Pandey & Kumar 1997) that indicate a
divergence between the norms and expectations of a center from the norms and expectations of the traditional academic department.
7. INSTITUTIONAL VARIATION ACROSS CENTERS

Despite evidence of heterogeneity across university research centers (Geiger 1990, Stahler & Tash 1994, Mallon 2004), above (in Chapter 3) I argue that centers share enough characteristics to be systematically distinguished from academic departments. This is a relative argument, one that (paraphrased) asserts: “centers differ more from departments than centers differ from each other.” Indeed, this argument is requisite to formulating hypotheses (in Chapter 6) regarding the impact of center affiliation on university scientists’ behaviors. If the norms and expectations of centers and departments do not differ in important and systematic ways, there can be no expected differences between the behaviors of scientists who affiliate with centers and the behaviors of scientists who do not.

Without abandoning this reasoning, I turn now to institutional variation across university research centers. Though centers, as a group, are distinguishable from academic departments, centers no less demonstrate important within group differences. Where one center is managed as a sub unit of an academic department, another is a standalone organization with no formal or informal ties to departments. Where one center is comprised of scientists from diverse backgrounds, another is comprised only of chemical engineers. Where one center originates in a major centers program such as those sponsored by the National Science Foundation (NSF), another has no programmatic ties but rather is the product of one or perhaps multiple principal investigator grants. Where one brings together tens if not over a hundred scientists from academia as well as from industry and government, another meets only the requirements outlined by the definition
of “university research center” provided in the 2004 RVM Program *Survey of Academic Researchers*.

My task in this chapter is to track institutional heterogeneity across university research centers, a task as difficult as chronicling the history of centers (see Chapter 2). This task is difficult because, as the definition of university research center employed can alter the starting point in time for an historical account of centers, so too can it affect the type and degree of variation one detects across centers. This definition establishes the criteria for demarcating what “counts” as a center from what does not count, thereby affecting the composition of the population within which variation is to be analyzed. For instance, the criterion “having ties with industry” excludes from the analysis numerous university research centers that, while they do not work with industry, are no less organizationally distinct from departments, in pursuit of problem focused research missions, and comprised of faculty from numerous fields and disciplines. Depending on the definition, one may find substantial or moderate or perhaps little to no heterogeneity across university research centers.

The definition of university research center employed in the 2004 *Survey*, reviewed (in Chapter 6) above, is about as broad as attempts at defining centers come (see Chapter 2 for a review of these definitions). Accordingly, great is the potential for institutional variation across the centers with which *Survey* respondents indicate affiliating. Before reviewing differences across these centers (using an ancillary data set to merge with the 2004 *Survey* data set), I review first a preliminary attempt at a typology of university research centers.

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56 I conduct this review not to make generalizations about university research centers in the U.S. (insofar as these centers do not constitute a representative sample of centers) but rather as prelude to the next chapter wherein I assess the impact of variation across these centers on their respective scientists’ time allocations.
Preliminary typology

While a definitive typology of centers goes beyond publicly available data, Bozeman & Boardman (2003) develop some elementary definitions based on RVM Program (www.rvm.gatech.edu) case analyses of university research centers. The distinctions in Table 14 propose for centers a “simple to complex” continuum across the parameters of university (or horizontal) relations, external relations, non research activities, and research focus.

Table 14. Taxonomy of university research centers

<table>
<thead>
<tr>
<th>Research Unit Type</th>
<th>Horizontal Relations</th>
<th>External Relations</th>
<th>Extra-Research Activities</th>
<th>Research Problem Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Department</td>
<td>Minimal, except for those pertaining to curriculum administration</td>
<td>Simple and decentralized</td>
<td>Teaching, university and professional service</td>
<td>Discipline-based, provides consensus for rewards system</td>
</tr>
<tr>
<td>Simple URC</td>
<td>Simple, sometimes no significant ones other than to department</td>
<td>Simple, negotiated by researchers interacting with networks of other academic researchers and government funding agencies</td>
<td>Few or none</td>
<td>Based on narrow set of problems, usually established by discipline-based “normal science”</td>
</tr>
<tr>
<td>Complex URC</td>
<td>Simple, sometimes no significant ones other than to department</td>
<td>Moderate complexity, including not only academic networks but other knowledge user types, especially industry</td>
<td>More extensive, including an expanded educational role, or industrial outreach, or brokering diverse network members</td>
<td>Mix of problem-driven topics and topics set by discipline or field specialization demands</td>
</tr>
<tr>
<td>MMURC</td>
<td>Varies, usually very complex, cutting across many units</td>
<td>Complex, often including multiple external industry, government, and university actors</td>
<td>Multiple, often including educational role, industrial interaction, scientific and professional brokering, community outreach</td>
<td>Almost entirely problem driven, not tracking closely to disciplines and established scientific and technical specializations</td>
</tr>
</tbody>
</table>

Source: Bozeman & Boardman (2003)

An important inclusion in the taxonomy is the academic department. In terms of university relations, external relations, and research focus, departments seem less “complex” than university research centers, even less so than “simple” centers.
Accordingly, an alternate interpretation of this typology may be that centers are
distinguishable not only per their respective levels of complexity, but also by how similar
or different they are in comparison to academic departments. (I return to this theme
below (in Chapter 8) when using role theory to formulate hypotheses about the expected
effects of center level characteristics on the composition of center scientists’ academic
work.)

The most complex of the university research centers (in the taxonomy) is the
“MMURC” or multipurpose multidiscipline university research center. According to the
authors, for a center to qualify as such it must meet the requirements of a “simple”
university research center but must extend beyond these requirements in pursuit of
research on some basis other than shared disciplinary focus, such as problem solution or
technology development and transfer. Though research focus is perhaps the key
distinction between less and more complex centers, with this distinction can come other
differences. For instance, a center comprised of scientists from numerous science and
engineering fields coordinating to develop technology for industry may have quite
different external relations than has a center focused on “normal science” and
dissemination of results by way of traditional peer reviewed media. The former center,
moreover, may have numerous and cross cutting relationships and reporting lines within
its home university while the latter may have but a single tie to an academic department.

However, even a center as complex in research mission as the MMURC may be
quite simple in its horizontal (or university) relations. It is not outside the realm of
possibility that an MMURC report to but a single department chair rather than engage in
the cross cutting relations suggested in the taxonomy above. A potential reason for such
instances is that the reporting lines of university research centers oftentimes are not preplanned but instead are a matter of historical accident, long standing personal relations, or convenience (Bozeman and Boardman 2003). Therefore, even within specific center “types” can there be variation.

**Variation within the MMURC “type”: the case of Engineering Research Centers**

Reviewed above (in Chapter 2), perhaps the best known university research centers are the NSF Engineering Research Centers (ERCs), all of which qualify as “multipurpose” and “multidiscipline” (Bozeman & Boardman 2004). Using data collected from ERC Web sites and from the Web site for the Engineering Research Centers Association (http://www.erc-assoc.org/), here I assess the extent to which all “active” ERCs indeed have complex horizontal and external relations, are multidisciplinary, and so on.\(^57\)

Of the eighteen currently active ERCs, all are enmeshed in complex relationships and reporting lines, both within and outside the university. Outside the university, all have formal industry partners and external advisory boards and all but three formally conjoin two or more universities.\(^58\) Inside the university, the majority (twelve) are “standalone” centers that have no apparent relationship with either academic departments or with colleges or schools that oversee departments. Of the remaining six ERCs, five mention (on their Web sites) affiliation with their home universities’ college or school of

\(^{57}\) An ERC is “active” if it is still receiving funding and other support from the NSF ERC program. For a list of all active ERCs, see http://www.erc-assoc.org/centers.htm. My analysis does not include ERCs that have “graduated” from the ERC program.

\(^{58}\) NSF ERCs that are “single university” centers include the Engineered Biomaterials ERC at the University of Washington, the ERC for Reconfigurable Machining Systems at the University of Michigan, and the Integrated Media Systems Center at the University of Southern California.
engineering, and the civil engineering department at the University of Illinois at Urbana Champaign claims to be the “headquarters” of the Mid-America Earthquake Center.59

Such homogeneity is to be expected across centers with common programmatic origins and, accordingly, with common criteria and expectations to meet and uphold. However, ERCs no less demonstrate some within group differences.

One of the hallmarks of university research centers is that, unlike traditional academic departments, they are comprised of faculty from diverse fields and disciplines (Ikenberry & Friedman 1972, Geiger 1990, Bozeman & Boardman 2004, Mallon 2004). Though all ERCs are “multidisciplinary” insofar as each is comprised of faculty from at least two fields or disciplines, these centers vary in their respective levels of multidisciplinarity.

Figure 21. The “multidisciplinarity” of active ERCs

Active ERCs, on average, are comprised of faculty from about six (5.8) fields.60 They have an inter quartile range of three fields or disciplines. The full range is from two to

59 See http://cee.uiuc.edu/portalresearch/centers.html. While this scenario certainly does not warrant categorizing the Mid-America Earthquake Center as “department based” and therefore as “less complex” than the other ERCs and than MMURCs more generally (see Table 8.1), in the next chapter I demonstrate that centers that are “smaller” than ERCs (e.g., in terms of number of scientists employed, programmatic origins) can indeed be managed as sub units of academic departments and, moreover, that these centers have different impacts on center affiliated university scientists than have centers with no ties to academic departments or do not originate in any majors centers program.
eleven fields or disciplines. This variation is likely the effect of the divergent research foci among ERCs. Some projects require input from more disciplinary orientations than require others.

Active ERCs also vary in the number of scientists they claim as faculty as well as in the number of universities and industry partners with which they have ties.

Figure 22. The “size” of active ERCs

Figure 23. The number of industry partners for active ERCs

\[60\] I used the NSF classification schema for delineating between fields.
On average, active ERCs are comprised of thirty four (33.9) scientists, partner with twenty eight private companies, and collaborate with four (4.2) universities (including the center’s home university). The box plots demonstrate fairly substantial variation across these measures. Active ERCs may claim as few as ten to as many as sixty two scientists, from eight to near ninety industry partners, and from one to ten university partners. I do not entertain further relationships here, such as quotients of scientists to disciplines or of disciplines to industry partners, not because these relationships are not interesting or because they are unimportant for gaining a better understanding of ERCs, but because the above descriptive measures are enough to warrant the claim that centers can vary across numerous attributes, even within specific centers programs.

**Variation across the university research centers indicated in the 2004 Survey**

In addition to indicating whether they affiliate with a university research center, respondents to the 2004 Survey were asked to list the name of the center with which they affiliate. Using this data in conjunction with respondents’ personal information, in particular the name of the university at which they work, I compiled a list of university research center names (and, importantly, center Web site addresses). From this list, I have
developed an ancillary data set tracking variation across the centers with which 2004 Survey respondents affiliate (see Appendix). This ancillary data set includes information regarding university research centers’ size, multidisciplinarity, university relations, programmatic origins (if any), and industry relations.

Not surprisingly, the data for these centers demonstrate substantially more variation than demonstrate the data for active ERCs. Consider the “size” (i.e., number of scientists) and “multidisciplinarity” (i.e., number of disciplines represented by center faculty) measures for this group of centers.

Figure 25. The “size” of the centers with which 2004 Survey respondents affiliate

![Graph showing size of centers]

Figure 26. The “multidisciplinarity” of the centers with which…

![Graph showing multidisciplinarity of centers]

These averages are not so far from those for active ERCs, with the 2004 Survey cohort of centers claiming as faculty, on average, about 20 scientists from 5 fields or disciplines. The inter quartile ranges are also close between the two groups. However,
notably different are the ranges and number of outliers. Perhaps because these centers do not constitute a random sample of centers in U.S. universities and also perhaps because they do not share common programmatic origins as share ERCs, the ranges are much broader for the 2004 Survey cohort of university research centers.

Many of the centers with which respondents indicated affiliation did not have Web sites as informative as those available for active ERCs. Accordingly, I was not able to make accurate counts for the remaining measures (which I make for ERCs above). Instead, I coded a series of binary variables indicating the nature of their horizontal (or university) relations, whether they have formal industry partners or an industry advisory board, and whether they are part of a larger centers program.

Like the active ERCs, a majority (67 percent) of the 2004 Survey cohort of centers are “standalone” centers with no apparent ties to academic departments or to colleges or schools than oversee academic departments. Twenty one percent of these centers indicated on their Web sites ties to a college or school, and four percent were managed off campus, usually at a not for profit or a state level facility. The remaining centers are organizationally affiliated within academic departments (see Appendix).

Over a third (37 percent) of these centers indicate on their Web sites having industry partners or an industrial advisory board. Eighteen percent are part of an NSF centers program, which includes ERCs, Science and Technology Centers, Industry/University Cooperative Research Centers, Materials Research Science and Engineering Centers, to name a few (see Appendix). Twenty four percent are part of centers programs sponsored by other agencies, including the National Institutes of
Health, Department of Energy, Department of Defense, NASA, NOAA, and State
Centers of Excellence, again to name a few (see Appendix).

In the next Chapter, I incorporate this data into the model specified earlier (in
Chapter 6) for predicting the expected time allocations of university scientists across their
research, teaching, grants and contracts, service, and advisory duties.
Because university research centers are not uniform, they do not affect center affiliated university scientists uniformly. Center norms and expectations are (at least in part) a function of center level attributes, and as center norms and expectations vary, so too may vary center scientists’ behaviors. But this variation does not mean much without a reference point. While centers certainly can be quite different from one another, there is still much more that (consistently) separates university research centers from traditional academic departments (see Chapter 3). This is the same argument I cite earlier as requisite for hypothesizing (in Chapter 6) about the impact of center affiliation on university scientists’ behaviors: “Centers differ more from departments than centers differ from each other.” Though not required in this chapter, the argument proves helpful when hypothesizing about the impact of institutional variation across centers. Centers and departments differ in important and systematic ways, and the more different is a center from the traditional academic department, the more different may be the behaviors of the university scientist who affiliates with both academic units.

When center norms and expectations diverge from those of the traditional academic departments, the “structural circumstance” (Merton 1957) of center induced role strain exists, to which center scientists may react by working longer hours (MacKinnon 1978). Absent this circumstance, center scientists are exposed to but one set of norms and expectations and therefore must contribute time and energy to fewer expected tasks and duties (see Chapters 5 and 6). In Chapter 6, I focused on whether a university scientist was affiliated with a center to “objectively” (e.g., Rizzo et al. 1970,
Pandey & Kumar 1997) identify (in the work environments of university scientists) exposure to the inter sender dimension of center induced role strain. In this chapter, I introduce into the model specification a series of center level variables designed to indicate when center norms and expectations are divergent from those of (typical) academic departments and when they are not, including variables measuring the number of disciplines represented by a center’s faculty membership, a center’s university relations, a center’s industry ties, and a center’s programmatic ties. Because these variables indicate (potential) qualitative distinctions between the norms and expectations of a center and those of an academic department rather than just a scientist’s “exposure” to center norms and expectations, they constitute “objective” evidence of the inter role dimension (rather than the inter sender dimension) of center induced role strain (see Chapter 1).

I use ordinary least squares regression61 to analyze the impact of these variables on the time that center scientists allocate to research, teaching, student advising, grants and contracts work, and service and committee duties. The data come from the 2004 Survey, though this time the data have been merged with the ancillary data set (introduced in Chapter 7) tracking heterogeneity across the centers with which Survey respondents indicate affiliation. Per my analysis above (in Chapters 5 and 6), I use role theory and in particular the concept of center induced role strain to formulate hypotheses

61 Because the distribution of each dependent variable is fairly normal, I use OLS regression for the models, as do most other studies of time allocation in the economics and sociology literatures. However, I also ran the models using Tobit and generalized linear regression techniques. I ran Tobit regressions because for some models the dependent variable had a large amount of zeros and the technique helps to arrive at more accurate estimator magnitudes. I ran Gamma (generalized linear) regressions because the theoretical range of the dependent variables is from zero to infinity and this type of regression technique is designed for continuous dependent variables that are bounded to be greater than zero. However, the Gamma estimators, being parameterized with an inverse power metric, are not directly comparable to the OLS and Tobit estimators.
and guide the analysis. Because in this chapter the number of explanatory variables increases substantially (from two in Chapter 6 to seven here), I do not state a formal hypothesis for each possible combination of the explanatory and dependent variables. I instead present general hypotheses “within the text.”

**Hypotheses for tasks encouraged by both centers and departments**

Above (in Chapter 3), I attempt to distinguish systematically university research centers from academic departments. If I have not succeeded fully in this task, it is because much “functional overlap” exists between the behaviors that centers and departments expect of their scientists. Both centers and departments typically expect of scientists the conduct of research as well as the performance of attendant tasks that are “part of the deal” of affiliating with both academic units, including grants and contracts work and service and committee duty. Such overlap is why I chose in the first place a “positional” (i.e., center vs. department) rather than a “functional” (e.g., research vs. teaching) approach to study the impact of centers on scientists.

But when there is “functional overlap” between center and department tasks and responsibilities, how does the center affiliated scientist distinguish? Role theory suggests they may distinguish in two ways, both related to the observation of “structural circumstances” (Merton 1957) whereby the norms and expectations of the center are identifiably separate and perhaps even qualitatively different from those of the department. One way is by center scientists or observers of center scientists\(^{62}\) identifying centers and departments as distinct organizations which both have legitimate claims on

---

\(^{62}\) When the focal individual acknowledges that norms and expectations are different, it is considered “subjective” evidence of role strain (e.g., Kahn et al. 1964, Pandey & Kumar 1997); when an outside observer makes the same acknowledgement about the same individual, it is considered “objective” evidence of role strain (e.g., Rizzo et al. 1970, Pandey & Kumar 1997). I review this distinction at length in Chapter 1.
their work time and energy. This constitutes the inter sender dimension of role strain emphasized in Chapter 6. Another way is by center scientists or observers of center scientists identifying center norms and expectations as qualitatively or substantively distinct from and perhaps conflicting with department norms and expectations. For instance, when working on center projects scientists may delay publication of work on industry related technology development but when working on department projects they may work on basic research for publication in peer reviewed media. This constitutes the inter role dimension of role strain emphasized in early applications of the concept of role strain to scientists (e.g., Goode 1960).

The interview data presented in Chapters 4 and 5 map closely with both ways of distinguishing, demonstrating that scientists can separate center from department expectations when centers have no formal or informal ties to departments (and therefore are organizationally distinct from departments) and when centers focus on research different from that which departments focus on (and therefore are substantively distinct from departments). Moreover, interviewees who could distinguish their center and department tasks and duties in either way in many instances indicated performing research and administrative “double duty” whereby they worked additional hours to meet center expectations in addition to department expectations.

In line with what both role theory and the interview data suggest, I dually hypothesize that (1) the more distinctive is a center’s university relations from an academic department and (2) the more distinctive is a center’s research focus from an academic department, the more time will center scientists allocate to the tasks that are expected of them by both academic units. The university relations of centers, in particular
whether they are managed by an academic department or by another unit in the broader context of the university, constitute evidence of the inter role dimension of center induced role strain whereby the center scientist is exposed to not only department demands and expectations but also to the demands and expectations of a center that is verified as organizationally distinct from an academic department. Here the case for the inter sender dimension of center induced role strain is much stronger than it was in Chapter 6 (that assessed center affiliation but ignored centers’ relations (or lack thereof) to departments). The research foci of centers, for instance when centers focus on prototype development for industry, constitute evidence of the inter role dimension of center induced role strain whereby the center scientist is exposed to not only department demands and expectations but also to center demands and expectations that are qualitatively (as well as organizationally) distinct from department demands. Fulfillment of organizationally and/or qualitatively different center and department demands and expectations will see an increase in the number of tasks the scientist must perform and therefore an increase in the hours worked (MacKinnon 1978) when compared to scientists beholden to fulfill only department demands and expectations as well as when compared to center scientists who affiliate with centers that have norms and expectations that are more similar or even identical to those of departments.

Tasks expected of scientists by both centers and departments (for which I have data) include research, grants and contracts work, and service and committee duty (see Chapter 3).
University relations

To control for a center’s university relations, I add to the model specification from Chapter 6 the following variables.

CTR_COLLEGE – A binary variable coded “1” if the center affiliates with a single college or school that oversees multiple departments, zero otherwise.

CTR_STDALN – A binary variable coded “1” if the center does not affiliate with a department, college, or school but no less resides on a university campus, zero otherwise. (This includes centers that are part of umbrella centers or institutes that are campus based, that report to university level offices of research, or indicate having no university linkages but are still campus based.)

CTR_OFFCAMP – A binary variable coded “1” if the center does not reside on a university campus but rather resides in a not for profit or government facility, zero otherwise.

The reference group for these mutually exclusive variables is comprised of centers that indicate organizational affiliation with a single academic department. Therefore each variable represents an alternate way in which a center can be organizationally distinct from departments.

Empirical research using role theory supports the idea of university relations enhancing or mitigating role strain and thereby increasing or decreasing workload. Miles (1977) and James and Jones (1976) demonstrate that as “management span” (i.e., the number of management tiers, intra and inter organizational) between a role sender and a
focal individual increases, so increases that individual’s reported incidence of the “structural circumstance” (Merton 1957) of role strain whereby, in this case (of the person-role dimension of role strain), the norms and expectations and values of the individual differ from those of management. Kahn and colleagues (1964) note, inversely, that when role senders and focal individuals are located in the same organization, they share the same goals, interests, and modus operandi, which decreases the incidence of role strain. Though I do not go so far as to combine the above university relations variables into a single ordinal variable wherein the “farther removed” is a center from the academic department the greater is the increase in time allocated to tasks expected of scientists by both centers and departments, the magnitudes of the estimators for these variables (in the results below) suggest exactly this.

Research focus

Because it is difficult (without extensive case study) to determine the precise nature of a center’s research focus, I use the following as proxies.

CTR_TOTDISC – A count variable indicating the number of fields or disciplines represented by the scientists working in a center.

CTR_INDUST – A binary variable coded “1” if the center has industry partners or an industrial advisory board, zero otherwise.

CTR_NSFW – A binary variable coded “1” if the center is sponsored by one of the many National Science Foundation centers programs, zero otherwise.
CTR_NONNSF – A binary variable coded “1” if the center is sponsored by one of the many centers programs that derive from other federal agencies or at the state level, zero otherwise.

Multidisciplinarity is one of the primary distinctions made between centers and departments (Mallon 2004, Bozeman & Boardman 2003, Stahler & Tash 1994, Geiger 1990, Ikenberry & Friedman 1972). It indicates a research focus (and therefore norms and expectations regarding the behavior of center scientists) that may be divergent from that of the typical academic department because the employ of scientists from numerous fields or disciplines usually (but not necessarily) coincides with the pursuit of problem focused research or with technology development. The remaining variables similarly may indicate a research focus divergent from those of departments, as external relations with industry and with formal centers programs that encourage technology transfer and other modes of industry interaction imply a problem focused or even a commercially relevant research bent.

Empirical research using role theory supports the idea of research focus enhancing or mitigating role strain and increasing or decreasing workload. Schuler (1977) shows that divergent and contradictory role expectations increase reports of role strain. Conversely, Stryker & Statham (1985) demonstrate that if an expectation from one source adheres to the norms or expectations of an external group, then role strain is minimized if not eliminated. MacKinnon (1978), moreover, demonstrates that role strain

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63 Despite increasing assertion that applied commercial research is becoming the norm on university campuses (e.g., Owen-Smith 2003, Etzkowitz 1998, Gibbons 1994, Slaughter & Leslie 1997), once the unit of analysis is ratcheted down to the department level there is considerable evidence to the contrary. Numerous studies (e.g., Siegel et al. 2003, Bozeman 1993, Porter & Rossini 1985, Brooks 1978) demonstrate in academic departments a bias (in tenure and promotion decisions as well as during research proposal reviews) against applied and commercially relevant research.
resulting from competing or contradictory role expectations can increase a focal individual’s workload. The above variables will help to indicate how divergent is a center’s expectations for research from those of academic departments.

**Hypotheses for teaching and student advising**

Up until now the hypotheses for the impact of institutional variation across centers have addressed time allocations to activities that are expected of center affiliated scientists by both centers and departments. No matter how centers differ from departments, the expected effect for activities for which there is “functional overlap” (Biddle 1979) is positive. However, for behaviors that are not expected by both centers and departments, there is probably not an additive effect but instead a substitutive effect.

Hypothesizing about the impact of institutional variation across centers on teaching and student advising is challenging insofar as these activities are expected by departments but typically not by centers (see Chapter 3). How can institutional variation across one institutional form affect the performance of a task induced by the expectations of another, distinct institutional form? It seems plausible that the more distinct are the norms and expectations of a center from those of the traditional academic department (either because centers and departments are organizationally distinct or because they have divergent research foci), the more likely will be the incidence of center induced role strain, discussed above. This incidence, in turn, may sap the time and energy a center scientist allocates to the department based activities of teaching and student advising.64

Interviews with center scientists suggest such a tradeoff between center related and

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64 Such a trade off is only partially supported in the literature. Though Shapiro (1978) and Massy and Zemsky (1994) suggest a tradeoff between time allocated to research and teaching, others (e.g., Braxton 1996, Milem et al. 2002) suggest a reinforcing relationship and still others (e.g., Feldman 1987) argue that research and teaching are unrelated in terms of relative time allocations.
student related activities (see Chapter 5). The results from Chapter 6, moreover, suggest a “buyout” scenario with the proportion of a scientist’s salary paid by the center decreasing hours allocated to teaching. Accordingly, I (tentatively) hypothesize that the more distinctive from an academic department is a center in terms of its university relations and research focus (see variable descriptions above), the less time will center scientists allocate to teaching and student advising.

**Model specification**

To determine how and the extent to which (if at all) institutional variation across university research centers affects the composition of center affiliated university scientists’ academic work, I specify the following model:

\[
\begin{align*}
\beta_0 + \beta_{1-8} & \text{CENTER CHARS} + \beta_9\% \text{ TIME ON CENTER WORK } + \\
\beta_{10} & \text{ SALARY FROM CENTER} + \beta_{11} \text{ GOV'T GRANTS} + \\
\beta_{12} & \text{ INDUSTRY GRANTS} + \beta_{13} \text{ QTY STUDENTS} + \\
\beta_{14} & \text{ QTY COLLABORATE} + \beta_{16} \text{ MARRIED} + \beta_{17} \text{ CHILDREN} + \\
\beta_{18-21} & \text{ DISCIPLINE} + \beta_{22} \text{ TENURE} + \beta_{23} \text{ MALE} + E
\end{align*}
\]

Where \(\beta_{1-8} \text{CENTER CHARS}\) is a vector of the above discussed center level variables,

\[
B_1 \text{SIZE}^{65} + \beta_2 \text{MULTIDISC} + \beta_3 \text{COLLEGE} + \beta_4 \text{STDALONE} + \\
\beta_5 \text{OFFCAMP} + \beta_6 \text{INDUST} + \beta_7 \text{NSF PGRM} + \beta_8 \text{NONNSF PGRM}
\]

And the rest of the model specification is identical to that used in Chapter 6.\(^{66}\)

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\(^{65}\) This variable, CTR_TOTSCI in the regressions below, is a control that counts the number of academic scientists working in a center.

\(^{66}\) The reference group is female biologists who are untenured but on the tenure track who have no children, are not married, have no grants, no students funded by grants, and no collaborators, and who affiliate with university research centers to which they devote zero percent of their research time and have zero percent of their salaries paid by their centers. The reference group’s respective centers are based in academic departments, do not affiliate formally with industry, are not part of NSF or non-NSF centers programs, have zero scientists working for them and also have zero disciplines represented by their faculty.
Results

The results confirm that center level characteristics, in addition to important individual level characteristics, can alter the composition of center scientists’ academic work.\textsuperscript{67} For the tasks expected by both centers and departments – research, grants and contracts work, and service and committee duties – many of the center level variables were statistically significant and positive. For teaching and student advising, no center level characteristics mattered, though the individual level variables measuring the percentage of research time a scientist devotes to center work each week and the percentage of a center scientist’s salary that is paid by a center retained their importance (from Chapter 6). I reserve discussion of the findings for the final section of this chapter.\textsuperscript{68}

\textsuperscript{67} Because the center level variables affect only center affiliated university scientists, I run the regression models for the sub sample of 2004 Survey respondents that indicate affiliation with a university research center. (There is actually no choice in the matter, unless I drop from the model specification the count variables for “multidisciplinarity” and “size.”) This reduces the number of observations to 499. Because the ancillary data set is still “under construction,” having collected data for centers with Web sites but still conducting phone interviews for centers without Web sites or without adequately informative Web sites (see Appendix), about 100 observations are dropped from the models.

\textsuperscript{68} In this chapter I present the results using OLS regressions for the models. The Appendix contains these results in addition to those for Tobit and Gamma regressions. From the OLS to the Tobit results, there were no changes in the statistical significance or directions of the estimators. There were slight changes in the magnitudes of the estimators from OLS to Tobit, with the Tobit estimators being slightly larger in magnitude. There were no changes in relative magnitude from the OLS to the Tobit estimators. For instance, in the model for hours per week allocated to research, the estimator for CTR_COLLEGE is smaller than that for CTR_STDALN, which is smaller than the estimator for CTR_OFFCAMP. From the OLS to the Gamma results, there were no changes in the statistical significance or directions of the estimators (keeping in mind that because the Gamma regression is parameterized using an inverse power metric, the signs should be reverse). There also were no changes in the relative magnitudes of the estimators.
<table>
<thead>
<tr>
<th></th>
<th><strong>HOURS PER WEEK ALLOCATED TO ACADEMIC TASKS</strong></th>
<th><strong>HOURS PER WEEK ALLOCATED TO RESEARCH</strong></th>
<th><strong>HOURS PER WEEK ALLOCATED TO TEACHING</strong></th>
<th><strong>HOURS PER WEEK ALLOCATED TO STUDENT ADVISING</strong></th>
<th><strong>HOURS PER WEEK ALLOCATED TO GRANTS AND CONTRACTS WORK</strong></th>
<th><strong>HOURS PER WEEK ALLOCATED TO ACADEMIC SERVICE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR_TOTSCI</td>
<td>-0.037 (0.028)</td>
<td>-0.004 (0.022)</td>
<td>0.012 (0.015)</td>
<td>-0.002 (0.004)</td>
<td>-0.030*** (0.011)</td>
<td>-0.016 (0.010)</td>
</tr>
<tr>
<td>CTR_TOTDISC</td>
<td>0.695* (0.363)</td>
<td>-0.188 (0.248)</td>
<td>0.014 (0.188)</td>
<td>0.048 (0.065)</td>
<td>0.395*** (0.125)</td>
<td>0.474*** (0.158)</td>
</tr>
<tr>
<td>CTR_COLLEGE</td>
<td>12.776 (15.624)</td>
<td>9.419* (5.569)</td>
<td>-0.960 (5.031)</td>
<td>0.311 (1.426)</td>
<td>2.054 (5.904)</td>
<td>1.835 (1.723)</td>
</tr>
<tr>
<td>CTR_STDALN</td>
<td>13.285 (15.512)</td>
<td>9.760* (5.504)</td>
<td>1.341 (5.093)</td>
<td>0.139 (1.403)</td>
<td>0.915 (5.839)</td>
<td>1.281 (1.689)</td>
</tr>
<tr>
<td>CTR_OFFCAMP</td>
<td>5.218 (16.278)</td>
<td>13.258* (7.377)</td>
<td>-7.204 (6.316)</td>
<td>-0.939 (1.645)</td>
<td>-0.396 (6.029)</td>
<td>0.406 (2.291)</td>
</tr>
<tr>
<td>CTR_INDUST</td>
<td>0.826 (1.937)</td>
<td>-1.140 (1.251)</td>
<td>-0.129 (1.087)</td>
<td>-0.029 (0.345)</td>
<td>0.673 (0.862)</td>
<td>1.432 (0.869)</td>
</tr>
<tr>
<td>CTR_NSFW</td>
<td>-1.228 (2.180)</td>
<td>-0.064 (1.292)</td>
<td>1.269 (1.305)</td>
<td>0.040 (0.498)</td>
<td>-1.647* (0.871)</td>
<td>-0.644 (1.059)</td>
</tr>
<tr>
<td>CTR_NONNSF</td>
<td>-1.435 (2.408)</td>
<td>0.186 (1.476)</td>
<td>-1.041 (1.297)</td>
<td>0.127 (0.472)</td>
<td>0.281 (0.892)</td>
<td>-1.136 (0.819)</td>
</tr>
<tr>
<td>CENT_SAL</td>
<td>-0.069* (0.041)</td>
<td>-0.036 (0.028)</td>
<td>-0.037* (0.022)</td>
<td>-0.016*** (0.006)</td>
<td>0.007 (0.015)</td>
<td>0.020 (0.028)</td>
</tr>
<tr>
<td>CENT_TIME</td>
<td>0.001 (0.034)</td>
<td>0.009 (0.025)</td>
<td>-0.034** (0.015)</td>
<td>0.004 (0.006)</td>
<td>-0.000 (0.011)</td>
<td>0.022 (0.014)</td>
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<tr>
<td>INDGRANTS</td>
<td>2.070* (1.184)</td>
<td>1.749*** (0.864)</td>
<td>-0.565 (0.606)</td>
<td>0.519 (0.434)</td>
<td>-0.183 (0.531)</td>
<td>0.568 (0.698)</td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td>0.182 (0.891)</td>
<td>0.162 (0.551)</td>
<td>-0.415 (0.485)</td>
<td>-0.069 (0.195)</td>
<td>0.103 (0.366)</td>
<td>0.332 (0.363)</td>
</tr>
<tr>
<td>TOTSTUD</td>
<td>0.182 (0.263)</td>
<td>0.163 (0.189)</td>
<td>-0.060 (0.106)</td>
<td>0.020 (0.029)</td>
<td>0.160 (0.113)</td>
<td>-0.087 (0.062)</td>
</tr>
<tr>
<td>TOTCOL</td>
<td>0.002 (0.110)</td>
<td>-0.050 (0.056)</td>
<td>0.001 (0.068)</td>
<td>0.008 (0.011)</td>
<td>0.084* (0.045)</td>
<td>-0.017 (0.027)</td>
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<td>ENG</td>
<td>-0.549 (4.152)</td>
<td>2.057 (2.309)</td>
<td>1.737 (3.161)</td>
<td>0.215 (0.514)</td>
<td>-1.192 (1.980)</td>
<td>-3.836** (1.928)</td>
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<td>Variable</td>
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<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
</tr>
<tr>
<td>-----------</td>
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<td>-----------------</td>
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<td>-----------------</td>
</tr>
<tr>
<td>AG</td>
<td>-5.130 (4.639)</td>
<td>-0.116 (2.672)</td>
<td>-2.250 (3.365)</td>
<td>1.157* (0.678)</td>
<td>0.562 (2.309)</td>
<td>-3.824* (2.237)</td>
</tr>
<tr>
<td>PHYS</td>
<td>-0.263 (4.208)</td>
<td>2.901 (2.446)</td>
<td>0.375 (3.083)</td>
<td>0.347 (0.523)</td>
<td>-0.557 (1.914)</td>
<td>-3.359* (1.910)</td>
</tr>
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<td>CS</td>
<td>-4.190 (4.669)</td>
<td>0.026 (2.626)</td>
<td>0.793 (3.478)</td>
<td>1.092 (0.861)</td>
<td>-2.104 (2.148)</td>
<td>-4.165** (2.027)</td>
</tr>
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<td>TENURED</td>
<td>-4.548*** (2.132)</td>
<td>-4.202*** (1.279)</td>
<td>-1.818 (1.374)</td>
<td>0.355 (0.288)</td>
<td>-1.563* (0.860)</td>
<td>2.825*** (0.564)</td>
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<tr>
<td>MALE</td>
<td>-0.213 (1.711)</td>
<td>2.416** (1.101)</td>
<td>-1.450 (0.977)</td>
<td>-0.753** (0.295)</td>
<td>-1.157* (0.681)</td>
<td>0.684 (0.702)</td>
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<td>MARRIED</td>
<td>-2.726 (2.392)</td>
<td>-2.303 (1.641)</td>
<td>-2.17 (1.525)</td>
<td>0.109 (0.420)</td>
<td>0.320 (1.247)</td>
<td>1.167 (0.757)</td>
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<td>CHILD</td>
<td>0.713 (0.778)</td>
<td>0.362 (0.441)</td>
<td>0.225 (0.430)</td>
<td>0.053 (0.168)</td>
<td>0.567* (0.315)</td>
<td>-0.470* (0.272)</td>
</tr>
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<td>RESPREF</td>
<td>1.204** (0.603)</td>
<td>-1.616** (0.689)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>39.798*** (15.483)</td>
<td>8.297 (6.007)</td>
<td>22.494*** (6.219)</td>
<td>1.524 (1.641)</td>
<td>6.644 (6.408)</td>
<td>1.557 (2.029)</td>
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<td>Observations</td>
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<td>378</td>
<td>382</td>
<td>382</td>
<td>382</td>
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<tr>
<td>R-squared</td>
<td>0.08</td>
<td>0.09</td>
<td>0.13</td>
<td>0.06</td>
<td>0.12</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses; * significant at 10%, ** significant at 5%, *** significant at 1%
Results for tasks encouraged by both centers and departments

Research

The variables for a center’s university ties are all statistically significant and positive for expected hours allocated to research. Holding all else equal, if a scientist’s center is part of a college or school (that oversees departments and potentially other centers) rather than part of a single academic department (CTR_COLLEGE), the expected number of hours the scientist allocates to research each week increases by over nine hours. If a scientist’s center is a “standalone” center but still resides on a university campus (CTR_STDALN), the expected number of hours allocated to research each week increases by nearly ten hours. Moving the center off campus and onto either state, federal, or not for profit property (CTR_OFFCAMP), the expected hours allocated to research each week increases by over thirteen hours.

Of the individual level variables, industry grants (INDGRANTS) is statistically significant, with each additional grant increasing the expected hours worked per week on research by almost two hours, all else equal. Having tenure (TENURED) and being male (MALE) are significant as well, respectively decreasing and increasing the expected hours a center scientist allocates to research each week.

Grants work and service duty

The proxies for a center’s research focus are statistically significant for expected hours allocated to grants and contracts work and to university based service and committee duties. For each additional discipline represented by a center’s faculty membership (CTR_TOTDISC), the expected hours allocated to grants and contracts work each week increases by twenty four minutes, all else equal. Each additional discipline
increases the expected hours allocated each week to service and committee duties by nearly thirty minutes.

There were also some reverse findings. If the center with which a scientist affiliates is part of an NSF centers program (CTR_NSF), the expected hours allocated each week to grants and contracts work decreases by an additional hour and thirty eight minutes. The number of scientists that a center claims as faculty (CTR_TOTSCI) too mitigates the expected time a center scientist allocates to grants and contracts work, by nearly two minutes per faculty member.

Of the individual level variables, total collaborators (TOTCOL) is statistically significant and positive for grants and contracts work, with each additional collaborator increasing the expected hours worked per week by about five minutes, all else equal. Having tenure (TENURED) and being male (MALE) both decrease the expected hours a center scientist allocates to grants and contracts work. In contrast, having tenure increases the expected hours a center scientist allocates each week to university based service and committee work, all else equal.

Results for teaching and student advising

No center level characteristic affects the time center scientists allocate on a weekly basis to teaching and to student advising. However, the individual level center related explanatory variables of key interest in Chapter 6 retain their statistical significance and directions of influence. Both the percentage of research time that a center scientist devotes to center work (CENTTIME) and the proportion of salary paid for by the center (CENTSAL) decrease the expected time center scientists allocate to teaching. For each percentage point of total research time a center scientist spends on
center based work, the center scientist teaches about two fewer minutes per week, all else equal. For each percentage point of salary covered by a center, the center scientist again teaches about two fewer minutes per week. For student advising, only CENTSAL is statistically significant, with each additional percentage point of salary paid by a center decreasing the time the center scientist allocates to this activity by about a minute, all else equal.

**Discussion**

The regression results demonstrate patterns that tell a preliminary story of how institutional variation across university research centers may affect the workaday lives of university scientists (in the U.S). Practically all of the above discussed ways that one center can vary from the next “matter” regarding center scientists’ time allocations across their academic work. Depending on the particular task or duty, however, some center level characteristics matter while others do not. Though I do not intend to discount the importance of individual level variation in explaining how center scientists allocate their work time, this discussion focuses on center level variation. Discussion of implications for both theory and policy are reserved for the next chapter.

The results suggest that time spent on research is in part a function of the other units in a university with which a center has relations. The further removed is a center organizationally from an academic department, the more research the center scientist seems to conduct. Scientists who affiliate with centers that are organizationally tied to but a single academic department allocate the fewest hours per week to research, followed by scientists whose centers are part of a college or school that oversees multiple departments (and in some cases multiple centers), then by scientists whose centers “stand alone” but
do so on campus, and finally by scientists whose centers are university affiliated but not on campus and, in some instances, are not university based.

Taken with the interview data presented above (in Chapters 4 and 5), this trend is perhaps indicative of the “structural circumstance” (Merton 1957) of the inter sender dimension of center induced role strain whereby center norms and expectations are distinct from department norms and expectations because the center and department operate as distinct academic units. When the center and department are organizationally intertwined, the degree of coordination and communication regarding what is expected of the scientists they share may increase and the likelihood of center induced role strain may decrease or be eliminated. The center scientist therefore may not fulfill distinct research obligations but instead conduct research that at once meets both department and center expectations. Conversely, when center and department are not organizationally intertwined, the degree of coordination and communication regarding what is expected of the scientists they share may decrease and the likelihood of center induced role strain may increase. The center scientist subsequently becomes obliged to fulfill distinct sets of expectations, which leads to an increase in the hours worked per week on research.

The results also suggest that time allocations to grants and contracts work and to service and committee duty are both in part functions of how closely a center’s research focus maps to a single discipline. The more multidisciplinary is a center’s faculty membership, the more time center scientists allocate to these non research tasks that, like research, are (typically) expected of scientists by both center and department. One interpretation is that the transaction cost (Williamson 1975) of coordination among scientists from numerous fields or disciplines is higher than it is when scientists from
fewer disciplines or from a single discipline coordinate, perhaps due to competing epistemological and organizational norms (Corley et al., In Press) or perhaps because of incentive misalignment and even goal divergence (Boardman & Bozeman, In Press).

Despite these trends, the story thus far leaves unanswered a few questions regarding how institutional variation across centers affects the composition of center scientists’ academic work. First, why does a center’s multidisciplinarity increase the expected time allocated to grants work and to service duty but not the time allocated to research? Though research conducted for a center may be multidisciplinary, it need not be “interdisciplinary.”69 Because the conduct of multidisciplinary research does not necessitate extensive interaction amongst scientists from disparate fields and disciplines, but just that scientists from disparate fields and disciplines work on different aspects of the same project (Ikenberry & Ikenberry 1982), coordination and transaction costs (and therefore time allocations) may not increase. For administrative work like that related to grants and service, however, the same scientists, though they conduct more or less “separate” research, must conjoin to “get things done.” Consider the example of proposal writing. Though the research proposed may be executed without too much interaction amongst the scientists, arriving at consensus about how to address a particular problem or research question may prove difficult (and therefore more time consuming) given the diversity of epistemological norms and methodologies represented across center faculty.

Another unaddressed question is why a center’s intra university ties affect the time center scientists allocate to research but not the time they allocate to grants work and service. Though academic departments may coordinate with centers to see that the

69 “Interdisciplinary” research occurs when faculty from different disciplines work together on the same project. “Multidisciplinary” research occurs when faculty from different disciplines work independently on different aspects of the same project (Friedman & Friedman 1982).
scientists they essentially share are not overworked in the research realm, for instance when departments “count” center based research in tenure and promotion decisions, it is perhaps much more difficult to “manage away” the just discussed transaction costs that may be incurred when scientists with different backgrounds coordinate on non research tasks and responsibilities. However, the results suggest that employing more scientists and affiliating with a major centers program may help to decrease the time center scientists allocate to grants and contracts work, perhaps by way of increased personnel and resources.
9. CONCLUSION

Over the past three decades, university research centers have been installed on a majority of university campuses in the U.S. to contribute to numerous missions, including local and regional economic development, resource pooling due to the increasing complexity and cost of research, national competitiveness and “hands on” scientific and technical training, to name a few. Because centers have become common in a relatively short amount of time, the conceptualization and articulation of their research missions has largely outpaced the conceptualization and articulation of their institutional missions. For instance, while all National Science Foundation ERCs by definition have missions of multidisciplinary research, engineering (re)education, and industrial collaboration (see p. 69), they do not have clear cut goals regarding faculty development and, related, how the centers should “fit” into the broader, department based culture of the university. Further, most studies of ERCs and of other university research centers evaluate the extent to which one or more component of centers’ research missions have been fulfilled. Accordingly, there is a dearth of theory based research aimed towards understanding the organization and management of centers. While there has been much focus on the research goals of centers, there has been less focus on centers’ institutional goals.

Focus on the institutional goals of centers can help to ensure that center scientists and administrators encounter as few barriers as possible in pursuit of center based research. University research centers must coexist among and share resources with other academic units on university campuses. If centers are to meet research goals efficiently and productively, it is important to understand how the institutional arrangement of
centers within the larger context of the universities that house them affects their faculty. As the analyses above show, particularly important is the level of “isolation” that centers have from the academic departments with which they share faculty in terms of both organization and research foci.

This concluding chapter will review and extend the major themes presented above. First, it will compartmentalize the empirical components vis-à-vis the theoretical components to reiterate the chief claims about center induced role strain and the theory and evidence used to support each claim. This section gets quite specific on the dimensions of role strain used and not used, on the data employed for each dimension, and on the strengths and weaknesses of each claim. Next, briefly reviewed are the implications of these claims for theory. As I mentioned at the outset of this study, as with most other applications (Biddle 1979, Pandey & Kumar 1997) use of role theory and the concept of role strain was first and foremost to frame a practical problem of science policy, not to further theory. No less this study poses minor implications for application of the concept of role strain to modern day university scientists as well as for human capital theories of time allocation. Last are the policy implications. In this section, hypothetical policy scenarios are presented as starting points to discuss how specified dimensions of center induced role strain may be alleviated. These scenarios are by design “extreme” and intended to demonstrate the difficulty of policy action regarding such alleviation. The final scenario considered is that center induced role strain cannot be alleviated but rather should be managed to ensure the job satisfaction and productivity of university scientists.
Empirical and theoretical components of the case for center induced role strain

In assessing the relationship between institutional variation across university research centers and the time allocations of center scientists, I argue that “center induced role strain” leads these scientists to work more on tasks and duties expected by both center and department and less on tasks and duties that are department only. I define center induced role strain as the general concept of role strain is defined, as an observable “structural circumstance” (Merton 1957) wherein an individual, the center scientist, is subjected to divergent and competing sets of norms and expectations (Goode 1960), one set emanating from a center and the other from an academic department. The observation of divergent norms and expectations may be made “subjectively” by the center scientist (e.g., Kahn et al. 1964, Pandey & Kumar 1997) or “objectively” by third parties observing the work environments of the subject (Rizzo et al. 1970, Pandey & Kumar 1997). Moreover, there are four types or “dimensions” (Kahn et al. 1964) of role strain to observe, either objectively or subjectively, not all of which apply to the concept of center induced role strain. The below table summarizes the specific claims made in the chapters above about the relationship between institutional variation across university research centers and the time allocations of center scientists. Indicated for each claim are the dimensions of role strain that apply and the data used to operationalize each dimension in support of each claim. (See Chapter 1 for a review of the dimensions of role strain.)
Table 16. Chief claims and the theoretical and empirical underpinnings for each

<table>
<thead>
<tr>
<th>Claim:</th>
<th>Role strain dimension:</th>
<th>Data source:</th>
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<tbody>
<tr>
<td></td>
<td>Inter-role</td>
<td>Inter-sender</td>
</tr>
<tr>
<td>1 When centers do not have ties with academic departments, center</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>scientists allocate more work time to research.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 When centers have relations with external stakeholders that have</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>traditionally “non academic” missions, center scientists allocate</td>
<td></td>
<td></td>
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<tr>
<td>more work time grants work and service and committee duty.</td>
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<tr>
<td>3 Center scientists allocate less work time to teaching, no matter</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>the nature of their centers’ internal and external relations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Center scientists harbor diverse values and goals that too influence</td>
<td>X</td>
<td>X</td>
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<td>their work time allocations.</td>
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Claim 1: The positive effect of “inter sender” role strain

The first claim (in Table 16) deals exclusively with the inter sender dimension of center induced role strain, which is experienced when a center scientist faces distinguishable (but not necessarily incompatible) expectations from her center and department (see Chapter 1). The interview data presented in Chapter 4 constitute “subjective” evidence of this dimension insofar as center scientists themselves indicate the extent to which they personally can distinguish their center work from their department work. More than half could make some a distinction. The interview data presented in Chapter 5 constitute additional “subjective” evidence of the inter sender dimension by demonstrating a coincidence in the ability to distinguish center from department work and comments about the lack of organizational ties, formal and informal, between one’s center and department. These reports demonstrate center scientists’ own perceptions of the “structural circumstance” (Merton 1957) of the inter
sender dimension of role strain that is the result of their center affiliation. In each of these
instances, center scientists reported having to perform “double duty” with respect to tasks
and duties generally expected by both centers and departments, including research, grants
work, and administrative duties.

A shortcoming of this data, being interview based, is that it relies on center
scientists’ reported perceptions and not on third party observation that the relationships
between their respective centers and departments are, as they report, essentially
nonexistent. Another shortcoming is that the sample from which the interview data
derives is small and nonrandom. The survey and ancillary centers level data presented in
Chapter 8 help to remedy these shortcomings and thereby strengthen the case that the
inter sender dimension of center induced role strain sees center scientists working more
on (at least some of) the academic tasks and duties expected by both centers and
departments.

The regression models in Chapter 8 include a series of mutually exclusive binary
variables indicating how a center is organizationally embedded within the larger context
of its home university. Included are variables indicating if the center with which a 2004
Survey respondent affiliates is managed by a college or school that oversees numerous
academic departments and potentially other centers, is “standalone” on a university
campus and reports only to the university’s office of research, or is located off campus
either on university property or non university property. The reference group of centers is
managed by an academic department. Because each of these variables represents a
different way in which a center can be organizationally distinct from an academic
department, each indicates “objective” evidence of the “structural circumstance” (Merton
1957) of the inter sender dimension of center induced role strain. The estimators for the binary variables were statistically significant and positive for center scientists’ hours per week allocated, on average, to research.

Though the employ of mixed methods render the case for Claim 1 somewhat stronger than if just one method was used, there are some obvious weaknesses. First, regarding the activities for which center scientists experiencing the inter sender dimension of center induced role strain must perform “double duty” (e.g., the conduct of distinct center and department research), there is disconnect between what the interview data suggest and what the survey data demonstrate. The interviews include reports of increases in time allocated not only to research but also to grants work and to service, while the survey data demonstrate an increase only in time allocated to research. One can only speculate for the current study about the reasons that underlay the limited findings from the survey data (see Chapter 8). Another weakness has to do with the inter sender dimension of role strain itself. As a concept, it does not contribute much to the discussion of the time constraints that center scientists confront. While it helps to identify when center expectations are indeed separate than department expectations, it does not explain how they are different. Its value is apparent only as a baseline from which to compare alternate (though not mutually exclusive) “structures” or “dimensions” of center induced role strain that reveal something about the substantive nature of center expectations versus department expectations.

Claim 2: The positive effect of “inter role” role strain

The second claim (in Table 16) deals exclusively with the inter role dimension of center induced role strain, which is experienced when a center scientist faces center
expectations that are substantively different and even incompatible with the expectations she faces from her academic department (see Chapter 1). The interview data presented in Chapter 5 constitute “subjective” evidence of the inter role dimension by demonstrating that center scientists who can distinguish their center work from their department work (in Chapter 4) also can distinguish the overarching research foci of their centers from the research interests of their departments. Many of these reports were accompanied by comments that their center research was not amenable to the production of research outputs valued by their departments in tenure and promotion decisions. These reports demonstrate center scientists’ own perceptions of the “structural circumstance” (Merton 1957) of the inter role dimension of role strain that is the result of their center affiliation. In each instance, center scientists reported having to perform “double duty” with respect to tasks and duties generally expected by both centers and departments, including not just research but also grants work and administration duties.

The shortcomings of this data are the same as those reviewed for Claim 1. The interview data are comprised of center scientists’ reported perceptions and not based on third party observation of the amenability of a center’s research program to the production of outputs valued by academic departments. Moreover, the sample from which the interview data derives is small and nonrandom. As with Claim 1, the survey and ancillary centers level data presented in Chapter 8 help to remedy (some but not all of) these shortcomings and thereby strengthen the case for the inter role dimension of center induced role strain seeing center scientists working more on (at least some of) the academic tasks and duties expected by both centers and departments.
The regression models in Chapter 8 include a series of variables indicating the extent to which a center’s research focus is “non academic” or deviant from traditional or “Mode 1” university research (Gibbons 1994). Included were binary variables indicating if the centers with which 2004 Survey respondents affiliate have industry ties or ties to a centers program (with a problem focused or economic development mission). Also included was a variable indicating the number of scientific fields or disciplines represented by centers’ faculty memberships. Though none of these variables measure directly the research focus of a center, each represents a distinction from the traditional academic department that is suggestive of an applied or problem-focused or even a commercially relevant center research focus. Accordingly, each measure indicates “objective” (albeit indirect) evidence of the “structural circumstance” (Merton 1957) of the inter role dimension of center induced role strain to which center scientists may be exposed. The estimator for the “multidisciplinarity” count variable was statistically significant and positive for hours per week allocated, on average, to grants work and to service and committee duty.

Though the employ of mixed methods render the case for Claim 2 somewhat strong, (as with Claim 1) there are some obvious weaknesses. Regarding the activities for which center scientists experiencing the inter role dimension of center induced role strain must perform “double duty” (e.g., the conduct of distinct center and department grants work), there is the same disconnect as identified for Claim 1 between what the interview data suggest and what the survey data demonstrate. The interviews include reports of increases in time allocated not only to grants work and to service but especially to research, while the survey data demonstrate an increase only in time allocated to grants
work and to service. Moreover, there is little in the interview data or regression results to explain why multidisciplinarity increases these time allocations but why, for example, a center having industry ties does not. Again, for the current study one can only speculate about the reasons that underlay the limited findings from the survey data (see Chapter 8).

**Claim 3: The negative effects on teaching**

The third claim (in Table 16) deals with both the inter sender and person-role dimensions of role strain, but the case for the former is relatively weak when compared to Claim 1 and is perhaps weaker than is the case for the latter. The interview data presented in Chapter 5 constitute “subjective” evidence of the inter sender dimension insofar as some center scientists who can distinguish their center work from their department work also report that their center tasks and duties take time away from their student related responsibilities. The above discussed qualifications about the interview data apply. The regression results presented in Chapter 6 constitute additional evidence of the inter sender dimension of center induced role strain insofar as the measures of center affiliation (i.e., the percentage of respondents’ research time devoted to center work and the percentage of respondents’ salaries paid by a center), both which were statistically significant and negative for hours allocated to teaching, indicates exposure to an additional set of workaday expectations.

However, the case for the inter sender dimension is rendered relatively weak by the non findings for the center level variables in the regressions in Chapter 8. None of the center level measures had a statistically significant effect on teaching or on student advising, though the individual level measures of center affiliation retained (from the Chapter 6 regressions) their statistical significance and (negative) direction of influence.
Accordingly, relative to Claim 1 there is limited “objective” evidence of the inter sender dimension of role strain because the individual level measures of center affiliation, while they represent exposure to an additional source of expectations, do not represent this “structural circumstance” (Merton 1957) as clearly as would have been the case if, for example, one or more of the variables measuring how a center is organizationally embedded in the larger context of the university were statistically significant.

This is not to suggest that center affiliation does not have a negative impact on university scientists’ time allocations to teaching and student advising, it of course does, but only that this negative impact may be unrelated to any particular center level characteristic. Per the regression results from Chapter 8, centers with industry ties do not detract more from scientists’ teaching and advising time allocations than detract “non industry” centers. Centers located off campus do not detract more from these activities than detract centers managed as sub units of academic departments. And so on.

Because only the individual level measures of center affiliation are statistically significant, the inter sender dimension becomes confounded with the person-role dimension of role strain, which occurs when an individual harbors self expectations and values that conflict with the expectations of one or more role senders. Perhaps center affiliated scientists who allocate more rather than less of their research time to center work do so because they value less their student related obligations and therefore allocate less time to these activities. Perhaps these scientists are more likely to have a proportion of their salaries paid by a center. This point of uncertainty regarding the “mechanism” (Lin 1998) or “structural circumstance” (Merton 1957) that explains center scientists’ time allocations to teaching underscores one of the drawbacks of focusing, as this study
focuses, on the roles of university scientists. When focusing on the impact of specific factors on behavior, undoubtedly overlooked are numerous other factors, in this case personal preferences and values and perhaps even alternate roles not considered here (Biddle 1979).

**Claim 4: The effects of individual characteristics and alternate roles**

The focus of this study (on how center norms and expectations may affect center scientists’ time allocations) intentionally deemphasizes other characteristics that may distinguish one university scientist’s workday scenario from the next. As shown in the chapters above, university scientists may be affiliated with centers or not, their centers may pay some or none or all of their salaries, they may conduct for their centers research for industrial clients or they may conduct research that is less applied or commercially relevant, their centers may be managed as a sub unit of their academic departments or their centers may be located off campus in a government facility. All of these factors can alter university scientists’ time allocations. However, university scientists may also have tenure or not, use grant monies to fund students or not, have industry and/or government grants or not, interact with industry or not, have numerous collaborators both in their departments and outside their universities and even abroad, and they may have families. Each of these factors can affect, as do center related factors, university scientists’ time allocations, no matter if the scientists affiliate with a university research center and, if they do affiliate, no matter the type.

The above analyses control for as many of these “alternate” (from the perspective of this study, not in relative importance) factors as the data allow. In Chapters 4 and 5 this allowance is limited as the interview protocol employed was focused on the impact
of center affiliation on the workaday lives of center scientists. In Chapters 6 and 8 this allowance is expanded as the 2004 RVM Program *Survey* was designed not only to elicit information about researchers’ center affiliations, but also to elicit information about numerous other aspects of researchers’ lives and perspectives, including their work environments, their scientific values, their collaboration patterns, their industry interactions, to name a few. The point is to observe whether center induced role strain retains its analytic power when accounting for as many of these “alternate” factors as possible.

Whether or not these factors constitute alternate roles that university scientists must fulfill is a matter of perspective and goal. As I discuss at the outset of Chapter 4 (on distinguishing the center role from the department role), roles may be defined by way of different rules for demarcating one role from the next, the most relevant to the study of scientists (and of professions more generally) being the functional (e.g., the teaching role versus the research role) and the positional (e.g., the center role versus the department role) rules of demarcation (Biddle 1979). Most studies of university scientists take the former approach to assess the intra sender dimension of role strain (see Chapter 1) that occurs within academic departments (e.g., Bowen & Sosa 1989). This study of course takes the latter approach to account for the competing expectations of centers and departments. The challenge is not in choosing the approach that befits the object of study, but rather to account for the shortcomings of the chosen approach.

Perhaps the biggest mistake that can be made when considering the position based roles that university scientists fulfill is to exclude the consideration of alternate positions. Insofar as the idea of the positional role is based on “context” (Biddle 1979), the center-
department demarcation seems to account for a majority of the norms and expectations to which university scientists are exposed. However, insofar as the idea of role strain is based on “structural circumstances” (Merton 1957) wherein the university scientist is exposed to norms and expectations that compete or conflict, the center-department demarcation, while interesting and certainly appropriate, seems to account for less.

For instance, within the department a university scientist may fulfill the role of department chair, doctoral program coordinator, or be the head of a hiring committee. Within the center a university scientist may fulfill the role of director, head a consulting project for an industry client, or be in charge of recruiting new scientists to work on center projects. Emphasized in the chapters above, a scientist may fulfill the role of an untenured scientist or that of associate or full professor. So there are numerous incarnations of center induced role strain yet to consider: that experienced by the departmental doctoral program coordinator who has consulting obligations in a center, by the assistant professor with no center based consulting obligations, the department chair who moonlights as a bench scientist in a center, to name a few. It is important to note, however, that each of these alternate positional roles point up dimensions of role strain that are emphasized in much previous study of scientists, including the intra sender and person-role dimensions and excluding those dimensions or “structural circumstances” that emerge when an individual obtains dual membership in competing organizations (Pandey & Kumar 1997). Further study is required to clarify how the inter sender and inter role dimensions of role strain, which occur when there are two or more competing role senders, are affected by the intra sender and person-role dimensions that occur within rather than across organizational boundaries.
Implications for theory

In addition to pointing up major questions about individuals who are subjected to multiple dimensions of role strain simultaneously, the findings pose a minor implication for the application of the concept of role strain to the study of professional scientists as well as an indirect implication for theories concerned in general with the way individuals allocate their time, whether at work, at home, wherever.

Using role theory to study scientists

The application of role theory to the study of scientists, especially to the study of scientists working in universities, requires two amendments. The first amendment is to deemphasize earlier focus on the preemptive minimization of role strain (see Goode 1960, Evan 1962, Box and Croton 1966) as a key goal of university scientists and of professional scientists more generally. For the study of “modern” university scientists who act as “academic capitalists” (Slaughter & Leslie 1997) in an environment of “steady state” funding (Ziman 1994), application of the role strain concept must be more similar to that of Gieryn (1983) wherein role strain does not necessitate behaviors leading to its diminution but rather becomes one of many factors that scientists weigh, for instance, when deciding whether to affiliate with a university research center.

The second amendment shifts focus from the individual to the institution. Though the unit of analysis of course must remain the scientist, the classical delineation of research institution “types” based on Merton’s (1957) public and private “clusters” of scientific values is too vague and perhaps inaccurate in today’s context of “Mode 2” university science (Gibbons 1994). The advent of university research centers renders

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70 Merton (1957) proposes three “clusters” of scientific values: “public,” “private,” and “instrumental” values. These clusters are built upon the extent to which a scientist values three general concepts:
the comparison of university to industry scientists (see Evan 1962, Box & Croton 1966) less interesting and policy relevant than within group comparisons of university scientists, including the comparison of center to non center scientists and the within group comparison of center affiliated scientists to one another.

**Predicting and explaining time allocations**

Use of the concept of role strain to predict and explain center affiliated scientists’ time allocations is not inconsistent with economic models of human capital investment positing that time is allocated across various alternatives based on the motivation for increased returns or “gain” (e.g., Rosen 1974, Singell *et al.* 1994). University scientists, though in center affiliation they may face the “structural circumstance” of role strain (Merton 1957) in which they are confronted with time constraints, they no less gain from center affiliation by way of the funds, equipment and infrastructure, collaborators, students, and so on, that centers provide. In scenarios where the motivation for gain or for increased returns may not be so apparent, for instance when a center scientist allocates a substantial amount of hours to service or committee work rather than to center based research using center equipment and monies, the idea of role strain provides perhaps a more “direct” explanation than provide alternate approaches emphasizing gain.

This is not to propose that the role strain approach may substitute for motivational explanations emphasizing gain. Combined, both approaches help to provide a more comprehensive explanation of center scientists’ time allocations across their academic

“autonomy,” “disciplinary communism,” and “personal commitment.” Autonomy is the extent to which the scientist can choose the topic and direction of research. Disciplinary communism is the importance the scientist attaches to publishing scientific results. Personal commitment is the scientist’s intrinsic interest in and subsequent dedication to the production of new knowledge. “Public” values are found in universities, which emphasize scientists’ autonomy and the publication of results in peer reviewed media. “Private” values are found in industry, which emphasize not publication nor autonomy but rather science directed towards capitalization on proprietary knowledge.
tasks and responsibilities. The role strain approach simply clarifies that while scientists are first and foremost motivated to allocate their time in as beneficial way as possible, they may no less be strained to behave in ways that on the surface seem less than beneficial.

**Implications for policy**

At the beginning of this chapter, I mention that while university research centers always have research goals, they usually do not have institutional goals regarding, for instance, the career development of center faculty and/or the “fit” of the center into the broader, department based culture of the university. To return to the example of ERCs, while these centers have very clear and detailed research goals, the institutional goal of “center organization” is perhaps under conceptualized and left to the discretion and “creativity” of center organizers. From the *ERC Best Practices Manual*:

“There is no ideal organizational scheme for an ERC; every center will be (and should be) unique. Indeed, the creativity your ERC team brings to the development of the center is apt to serve as a model for future developments within your home institution. There are, however, two things you can count on: change, and the need to be flexible” (ERC Best Practices Manual, Section 6.2)71.

While acknowledged is that the way a center organizes may be important, it barely hints at the management challenges that centers face in pursuit of their research missions. University research centers must coexist and share resources, most notably faculty, with other academic units on university campuses, most notably academic departments. The competition and even conflict over resources among diverse academic units can have

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71 Viewed online at http://erc-assoc.org/manual/bp_ch6_2.htm on 08/30/06.
numerous outcomes (Stahler & Tash 1994), including the dimensions of center induced role strain analyzed above.

What should be the broad based institutional goals of a university research center has been reviewed elsewhere (Boardman & Bozeman 2003). Here the focus is strictly on what the chief claims of this study imply for policies regarding the institutional arrangements and goals of university research centers. In this section, hypothetical policy scenarios are presented as starting points to discuss how specified dimensions of center induced role strain may be alleviated. These scenarios are by design “extreme” and intended to highlight the difficulty and challenge of policy action regarding such alleviation. The final scenario considered is the most realistic perhaps, that center induced role strain cannot be alleviated but rather may kept at a manageable level to ensure the productivity of university scientists.

**Scenario 1: Mandatory relations between centers and departments**

The instinctive reaction to Claim 1, reviewed above (see Table 16), is to mandate that university research centers make ties with the academic departments with which they share faculty. This way, coordination and cooperation between centers and departments regarding what is expected of center scientists is ensured, and alleviated is their exposure to the “structural circumstance” (Merton 1957) of the inter sender dimension of center induced role strain (see Table 1 in Chapter 1). But unclear are the types of “ties” and therefore the extent of coordination and cooperation required. If the center is managed formally as a sub unit of an academic department, inter sender role strain may be eliminated but perhaps at the cost of substituting center goals for department goals. If center-department ties are more egalitarian, the inter sender dimension of center induced
role strain cannot be eliminated entirely but may be alleviated to the point where the center scientist can meet both center and department expectations without “overextending” and without sacrificing productivity and quality (Hampel 2002) regarding not just research, but all academic tasks and duties.

The latter scenario is of course “optimal,” but the tacks that may lead to such optimization are so numerous and context dependent that it fails to adequately inform policy action. Consider, moreover, centers with faculty memberships from a multitude of departments as well as differences between the behaviors and outputs that centers and departments value (see Scenario 2 below). One can envision the transaction costs (Williamson 1975) of mandated relations between centers and departments increasing to the point that the institutional goals of centers supersede the research goals. Required then are not mandated relations between centers and departments which share faculty, but rather policy that sees centers and departments interacting “voluntarily” or “naturally.”

Scenario 2: Alteration of the traditional academic reward template

The instinctive reaction to Claim 2, reviewed above (see Table 16), is to mandate that academic departments consider in tenure and promotion decisions the research outputs generated as well as the other activities conducted within university research centers. This way, divergence in the substantive nature of what is expected of center

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72 ERC Program Director Lynn Preston emphasizes in her report to the ASEE Engineering Research Council the importance of tenure and promotion committees attributing equal weight to cross-disciplinary and single discipline work and ensuring that senior ERC faculty see that junior-level scientists publish their center research in journals that are valued by their academic departments as well as by their centers. However, while certainly this is an important issue regarding the perceived gap between university research missions and the university reward system, it overlooks our focus here on applied and commercially-relevant research, which does not always result in publication but rather, ideally, in technology transfer of one form or another. Scholars too offer many policy prescriptions for broadening the scope of outcomes that count in tenure and promotion decisions. Braxton and Bayer (1986) employ the broadest prescription, counting any activity that requires disciplinary knowledge and skill. Others (Shulman and Hutchings, 1998; Diamond, 1993, 1999; Glassick et al., 1997; Braxton et al., 2002) get more specific, advocating criteria.
scientists by centers and by departments is minimized if not eliminated, and alleviated is the “structural circumstance” (Merton 1957) of the inter role dimension of center induced role strain (see Table 1 in Chapter 1). However, despite evidence of departments becoming more applied and interdisciplinary (e.g., Morris 2002), there is evidence still that they lack the capacity or the willingness (or both) to evaluate center based work and outputs (e.g., Siegel et al. 2003). Moreover, the traditional academic reward template has resisted for decades the systematic consideration of the gamut of tasks and activities performed by university scientists within departments alone (Boyer 1990, Braxton & Del Favero 1996), rendering quite unlikely the systematic consideration of tasks and activities that university scientists conduct outside departments.

Even if departments had the capacity and willingness to consider in tenure and promotion decisions center outputs and activities, the problems of feasibility discussed for Scenario 1 above emerge, though this time from the perspective of the department

with which to categorize an activity, including but not limited to publishing in peer-reviewed journals or books, as “scholarly” or not. The criteria include the publicness, amenability to peer review, replicability, documentability, impact, and innovativeness of an activity – be it publishing, basic or applied research, teaching, collaborating with industry, developing prototypes, mentoring graduate students, to name a few. A quick review of this short list nevertheless reveals why the traditional university reward system has persisted, more or less unchanged, for so long. Some of the criteria are simply difficult to conceptualize due to vagueness (publicness, impact, innovativeness), while others are most easily conceptualized as a consequence of publishing. To illustrate the latter, it is hard to imagine how a scientist at the University of California could replicate an experiment conducted by a scientist at Georgia Tech without the Georgia Tech scientist first publishing her research methods and results in a journal read widely by scientists in her discipline or field. Similarly, publication renders scientific research more amenable to peer review, documentability, and impact. Only the criteria of innovativeness lends itself to the type of revision of the university reward system that our results imply are necessary for junior-level MMURC scientists to place a higher value on applied and commercially-relevant research vis-à-vis basic research geared primarily towards publication.

73 Brooks (1978) argues that departmental peer review is suitable for defined fields but not for interdisciplinary fields, and for assessing new knowledge for its own sake but not for measuring the usefulness or applicability of that knowledge. More recently, Bozeman (1993) suggests that peer review is ill-suited for assessing commercially-relevant work, while Siegel and colleagues (2003) suggest that there may be bias in tenure and promotion decisions favoring single-discipline and basic research over applied and commercially-relevant projects.

74 The converse charge probably cannot be made. Though not all department scientists are center scientists, generally most center scientists are department scientists.
rather from that of the center. The research foci of and attendant behaviors and outputs
valued by university research centers are anything but uniform (Geiger 1990), and
departments with diverse faculty harboring varied research interests may potentially have
to consider in tenure and promotion decisions not just the behaviors and outputs valued
by one center but those valued by numerous centers. Again, one can envision an increase
in the transaction costs of such consideration to the point that institutional goals
supersede research goals. As with Scenario 1 mandating relations between centers and
departments, mandating that departments value what centers value does not help centers
and departments to interact “voluntarily” or “naturally.”

**Scenario 3: Keep center faculty and department faculty separate**

Claim 3, reviewed above (see Table 16), has inspired some to argue that the
missions of universities should be kept separate from those related to economic
development and competitiveness (e.g., Slaughter & Leslie 1997). Taken with the
feasibility problems posed by Scenarios 1 and 2, keeping center faculty and department
faculty separate seems a reasonable solution to the science policy problem of center
induced role strain. This way, university scientists are not beholden to divergent norms
and expectations and alleviated are the “structural circumstance[s]” (Merton 1957) of
both the inter sender and inter role dimensions of center induced role strain (see Table 1
in Chapter 1). However, this option has been ruled out by a number of centers programs
already, including the ERC program, in that it may avert from achieving center research
goals efficiently and productively. For example, keeping center and department faculty
separate could see university research centers becoming homes for “academic refugees”
who do not apply for tenure in a department or who do apply but are denied tenure
(Boardman & Bozeman, In Press). In addition to detracting from the quality of scientist working in centers, keeping center and department faculty separate could also avert from the educational missions of some of the larger centers programs, again such as the ERC program, by limiting access to students. What this suggests is that center induced role strain is not an unforeseen consequence of centers policies and programs but rather a calculated risk of centers programs as it is for the scientists who choose to dually affiliate with centers and departments.

**Scenario 4: Mandatory institutional (versus research) goals for centers**

Barring a massive cultural upheaval in the U.S. university system or a change in centers programs allowing the employ of scientists who do not have appointments in academic departments, center induced role strain will remain a fixture of university culture. One director of an STC 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 university scientist’s choice is to either opt out, thereby foregoing the considerable resources of the center, or to join the center and seek to balance the demands of an ever more complex work environment. For those scientists who do not opt out, there are foreseeable policy actions that may help to keep center induced role strain at reasonable “levels.”

The above policy scenarios were “extreme” cases wherein existing academic norms and institutions were dramatically (and shortsightedly) altered to eliminate divergence between center and department norms and expectations. While these scenarios are not actionable, they are suggestive of policy actions that may help to reduce
center induced role strain. For instance, while it may be imprudent to add ad hoc center outputs and activities to the list of the outputs and activities traditionally rewarded in department tenure and promotion decisions, it is not unreasonable for centers programs to mandate that their centers have strategic guidelines related to faculty development. Further, while it may be imprudent to mandate formal ties between centers and departments that share academic faculty, it is not unreasonable for centers programs to mandate that their centers articulate strategic guidelines for situating in the larger context of the university that opens up communications and decreases the potential for competition over resources, including but not limited to faculty. The point is to ensure that centers consider where they are headed as academic institutions in addition to where they are headed in terms of research. As with the ERC Best Practices Manual recommendation for the organization of ERCs, such consideration will have to occur at the center level, on a center by center basis.

While moderate and somewhat unexciting and intentionally vague, these or comparable actions are all that realistically may be implemented so long as academic departments remain the primary academic unit in U.S. universities and, related, so long as the traditional academic reward template emphasizes publications over alternate scientific outputs and activities.

**Additional questions to consider**

One question that this study fails to address is whether “center induced role strain” and the increased workload that results from affiliation with centers with certain characteristics is necessarily a problem worthy of policy makers’ and researchers’ attention. Scientists who affiliate with centers opt to work more hours and to endure in
organizational role strain on top of the intra organizational role strain they endure already from within their academic departments. What is required is future research assessing the relationship of center induced role strain and the attendant increase in work load to scientific productivity and perhaps even to reports of job satisfaction. Arguably, researchers who are more focused may well be more productive, even working fewer hours and having fewer resources. Arguably, researchers who have the pressures of dual or multiple allegiance may be less satisfied with their careers and have a higher “drop out” (from academic careers) rate than those who do not.
APPENDIX

The survey data

The Research Value Mapping “Survey of Academic Researchers” is a study by researchers at Georgia Tech’s Research Value Mapping Program (RVM) of a representative sample of more than 1,600 academic faculty in the sciences and engineering. The project, started in 2004 and completed in 2005, is based on a variety of data sources, including mailed questionnaire responses, secondary data about universities and university research centers and data drawn from curricula vitae of the respondents. The present appendix addresses only from the questionnaire data. See Appendix 2 for an overview of the ancillary data on university research centers.

Sample

The RVM project directors (Barry Bozeman, PI, Juan Rogers, PI) developed a sampling frame to represent the population of academic researchers working in “Carnegie Extensive” (formerly known as “Research I”) universities (see Carnegie, 2000). This rendered a list of 150 universities that produced at least one Ph.D. in 2000 in at least one of the following science and engineering disciplines: biology, computer science, mathematics, physics, earth and atmospheric science, chemistry, agriculture, sociology, chemical engineering, civil engineering, electrical engineering, mechanical engineering, and materials engineering. Health sciences and economics were excluded from the NSF definition of science and engineering (NSF 2000), and engineering was represented by five of its major specialties.

After determining the target population of universities and disciplines, RVM collected the names of tenured and tenure track faculty for each university by discipline.
Faculty names were retrieved from a variety of sources, including Web based university catalogs and departmental Web sites. The resultant sampling frame included 36,874 scientists and engineers occupying either a tenure track or tenured position in an academic department. The target sample was two hundred men and the same number of women from each of the above listed disciplines. Because the respective sizes of the disciplines vary, as does the representation of women in each discipline, the sampling proportions for women varied from 0.21 (biology) to 1.0 in five disciplines (agriculture, materials engineering, mechanical engineering, civil engineering, chemical engineering). The sampling proportions for men varied from 0.06 in biology, to 0.23 in agriculture. The final target sample was 4,916 scientists and engineers.

**Survey administration**

Administered by mail in accordance with Dillman’s (2000) “tailored design method,” the survey focused in content on the following domains of faculty activity: funding, collaboration, institutional affiliations, career trajectory, and distribution of work effort. The survey also included questions designed to obtain basic demographic information about the scientists, their work related motivations and values, and the perceived benefits they gain from their work.

After four waves (initial mailing, reminder post card, second mailing, third mailing) the survey administration phase was terminated with a response rate of thirty eight percent. For the population of university scientists, this response rate is comparatively high and the possibilities for determining response bias are enhanced by the fact that the RVM researchers were able to compare the resultant sample to known parameters of the population (e.g. scientific fields, gender composition). Furthermore a
“wave analysis,” correlating all items with each of the three waves of response (wave 1 \(n=1372\), wave 2 \(n=449\), wave 3 \(n=449\)), indicated no significant differences in response patterns by either wave or date received, indicating that non-respondents, who are theoretically more like late or third wave respondents, are not significantly different than respondents.

However, scientists who responded in later waves were slightly more likely to rank as important reasons to collaborate with other scientists the “desire to work with researchers whose skills complement my own” and “quality of previous collaborations.” Later respondents were slightly more likely to indicate having spent more time working with researchers in nations other than the United States and with researchers at other universities. They were also slightly more likely to agree that they enjoy research more than teaching and to allocate time to supported and independent research. Demographically, they were more likely to be Caucasian, more likely to be an American citizen, and more likely to work in the field of physics.

**Descriptive statistics**

Table 17 contains means and standard deviations of the sample characteristics included in the model specification for Chapter 6 (i.e., in the model specification that does not include centers level variables). I add to this table the binary variable that is coded “1” if a respondent indicates affiliation with a center, zero otherwise (CENTAFF). After correcting for coder error and respondent error (see below), I find that thirty percent of researchers affiliate with university research centers, versus larger estimates using the same data but without accounting for such error (e.g., Corley & Gaughan 2005). The average proportion of center affiliated respondents’ respective salaries paid by a center
(CENTSAL) is 3 percent. The average percentage of their research related work time that they devote to center based work (CENTTIME) is around 9 percent.

Table 17. Means and standard deviations of the explanatory and control variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTAFF</td>
<td>1644</td>
<td>.303528</td>
<td>.4599211</td>
</tr>
<tr>
<td>CENTTIME</td>
<td>1644</td>
<td>8.559002</td>
<td>21.68981</td>
</tr>
<tr>
<td>CENTSAL</td>
<td>1644</td>
<td>2.821077</td>
<td>11.75448</td>
</tr>
<tr>
<td>INGRANTS</td>
<td>1644</td>
<td>.1441606</td>
<td>.4377458</td>
</tr>
<tr>
<td>GOVGRANTS</td>
<td>1644</td>
<td>1.166358</td>
<td>.9464242</td>
</tr>
<tr>
<td>TOTSTUD</td>
<td>1642</td>
<td>4.016443</td>
<td>4.353692</td>
</tr>
<tr>
<td>TOTCOL</td>
<td>1640</td>
<td>12.94146</td>
<td>44.1943</td>
</tr>
<tr>
<td>TENURED</td>
<td>1644</td>
<td>.7293187</td>
<td>.4444469</td>
</tr>
<tr>
<td>MARRIED</td>
<td>1603</td>
<td>.8577667</td>
<td>.3493983</td>
</tr>
<tr>
<td>CHILD</td>
<td>1643</td>
<td>.8502739</td>
<td>1.096214</td>
</tr>
<tr>
<td>MALE</td>
<td>1644</td>
<td>.4854015</td>
<td>.4999389</td>
</tr>
<tr>
<td>AG</td>
<td>1644</td>
<td>.0827251</td>
<td>.27555</td>
</tr>
<tr>
<td>CS</td>
<td>1644</td>
<td>.0839416</td>
<td>.2773846</td>
</tr>
<tr>
<td>PHYS</td>
<td>1644</td>
<td>.3485401</td>
<td>.476653</td>
</tr>
<tr>
<td>ENG</td>
<td>1644</td>
<td>.4081509</td>
<td>.4916409</td>
</tr>
</tbody>
</table>

Almost 75 percent of the respondents are tenured, roughly reflecting the proportion of tenured professors in Research Extensive universities (Carnegie 2000). Reflecting the over sample of women, about half of the respondents are male. Not included in the table, slightly less than one tenth of respondents came from each discipline. In this study, I use biology as the reference disciplinary category. After evaluating the effects of collapsing categories and finding none, almost 35 percent of the sample are physical scientists (physics, chemistry, mathematics, and earth and
atmospheric science), 41 percent are engineers (civil, chemical, electrical, materials, mechanical), 8 percent are in agricultural science, 8 percent are computer scientists, and the remaining ten percent are biologists.

The key dependent variables are hour count variables for the average weekly work time allocated to academic tasks and duties, including research, teaching, grants and contracts work, and service and committee duties. Table 18 contains the means and standard deviations for each.

Table 18. Means and standard deviations for the dependent variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total academic time worked per week</td>
<td>1637</td>
<td>49.12068</td>
<td>20.48786</td>
</tr>
<tr>
<td>(in hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total hours worked per week on research</td>
<td>1639</td>
<td>17.72819</td>
<td>10.54216</td>
</tr>
<tr>
<td>Total hours worked per week on teaching</td>
<td>1638</td>
<td>16.00162</td>
<td>9.780772</td>
</tr>
<tr>
<td>Total hours worked per week advising</td>
<td>1638</td>
<td>2.471551</td>
<td>3.017828</td>
</tr>
<tr>
<td>students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total hours worked per week on grants</td>
<td>1639</td>
<td>7.524259</td>
<td>6.831399</td>
</tr>
<tr>
<td>and contracts work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total hours worked per week on university</td>
<td>1639</td>
<td>5.196919</td>
<td>6.494585</td>
</tr>
<tr>
<td>based service and committee duty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On average the respondents work near 50 hours per week, with the most hours allocated on average to research (almost 18 hours), followed by teaching, grants and contracts work, university based service and committee work, and student advising. I omit from my analysis variables measuring the time allocated per week to paid consulting and to professional and community service that is not part of university based service insofar as these tasks do not constitute “academic work,” my focus in this study, at least not in any direct sense.
Many of the above variables were calculated from more granular time allocation variables. Table 19 contains the means and standard deviations for each. Time allocated to advising students and to university based service are not included because they are included in Table 18 above.

Table 19. Means and standard deviations for all of the time allocation variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hours worked per week on proposal writing</td>
<td>1639</td>
<td>5.051281</td>
<td>5.321909</td>
</tr>
<tr>
<td>Total hours worked per week on grants based research</td>
<td>1639</td>
<td>12.79695</td>
<td>9.443825</td>
</tr>
<tr>
<td>Total hours worked per week on independent research</td>
<td>1639</td>
<td>4.878768</td>
<td>6.809642</td>
</tr>
<tr>
<td>Total hours worked per week on grants and contracts admin.</td>
<td>1639</td>
<td>2.472977</td>
<td>3.342186</td>
</tr>
<tr>
<td>Total hours worked per week teaching undergraduates</td>
<td>1639</td>
<td>9.631483</td>
<td>8.281392</td>
</tr>
<tr>
<td>Total hours worked per week teaching graduate students</td>
<td>1638</td>
<td>6.37036</td>
<td>6.310644</td>
</tr>
<tr>
<td>Total hours worked per week on non university service</td>
<td>1639</td>
<td>2.563301</td>
<td>3.464753</td>
</tr>
<tr>
<td>Total hours worked per week on paid consulting</td>
<td>1638</td>
<td>.5324481</td>
<td>1.655046</td>
</tr>
</tbody>
</table>

I do not use many of these measures in my analysis insofar as they are amenable to less meaningful comparisons than are the summed variables in Table 19 above. Most debate surrounding the way university scientists spend their workaday hours revolves around more general comparisons (e.g., teaching versus research) (e.g., Shapiro 1978).

**Determining whether a center is a center**

In the 2004 *Survey*, respondents were asked to indicate if they affiliate with a university research center and, if so, to name the center with which they are affiliated. The definition of university research center provided in the *Survey* reads as follows: “A university research center is ‘a research institution that has five or more faculty and
postdoctoral researchers and includes participants from more than one discipline and more than one academic department.” Perhaps because of the broadness of this definition, many respondents listed as “university research centers” either their academic department or home university. Some went so far as to list both. Accordingly, in the data set I have replaced “1” codes with zero codes for the binary variable indicating center affiliation (CENTAFF) for the following types of entries:

- Universities
- Colleges or schools that oversee multiple academic departments
- Academic departments
- Centers that focus on education but do not conduct research
- Political organizations
- Advocacy organizations
- Hospitals

This has rendered a more modest rate of center affiliation than that indicated in previous study using the 2004 Survey data set (e.g., Gaughan & Corley 2005). The mean value for CENTAFF is .304, indicating that approximately 30 percent of university scientists in the sample affiliate with a university research center.
The centers data

In addition to indicating whether they affiliate with a university research center, respondents to the 2004 Survey (see Appendix above) were asked to list the name of the center with which they affiliate. Using this data in conjunction with respondents’ personal information, in particular the name of the university at which they work and their scientific discipline, I compiled (through web-searches) a list of university research center names and center Web site addresses. From this list, I developed an ancillary data set tracking variation across the centers with which 2004 Survey respondents affiliate (see Appendix). This ancillary data set includes information regarding university research centers’ size, multidisciplinarity, university relations, programmatic origins (if any), and industry relations.

Verifying the list of centers

In many instances respondents listed the name of the university research center with which they affiliate in clear enough terms to confirm with ease that the respondent indeed was an affiliate of the indicated center. However, in some instances respondents list an abbreviated name or simply initials. In these cases, a number of measures were taken to ensure that the correct center was identified for each respondent indicating center affiliation. The first measure was to conduct a search on the respondent’s home university Web site for the center name indicated in the 2004 Survey. The second measure was to search the Web site for the respondent’s academic department to locate any mention of the center(s) with which the respondent affiliates. The third measure was to locate respondent’s curriculum vitae and search therein for any mention of the center(s) with which the respondent affiliates. The fourth measure was to conduct a Google search using
some combination of the respondent’s name, the respondent’s university name, and the name of the center with which the respondent indicated affiliation. After this lengthy process, the correct center was identified for each respondent indicating center affiliation, though in approximately ten percent of the instances the “center” listed turned out to be either an academic department or some other organization that does not “count” as a university research center.

**Determining whether a center is a center**

The definition of university research center provided in the *Survey* reads as follows: “A university research center is ‘a research institution that has five or more faculty and postdoctoral researchers and includes participants from more than one discipline and more than one academic department.’” Perhaps because of the broadness of this definition, some respondents listed as “university research centers” either their academic department or home university. Some went so far as to list both. The following types of entries I do not consider to be university research centers:

- Universities
- Colleges or schools that oversee multiple academic departments
- Academic departments
- Centers that focus on education but do not conduct research
- Political organizations
- Advocacy organizations
- Hospitals
Data collection

The final list of variables to collect data for included variables indicating the other academic units in the university to which a center has ties, the number of disciplines represented by a center’s faculty membership, the number of academic scientists working in a center as center faculty, whether a center has an industrial advisory board or industry partners, and whether a center is part of a formal centers program. These are listed in separate tables below followed by some comments on challenges to validly coding these variables from information posted on center Web sites.

Management context variables

Designed to indicate how a center relates to other academic units in the university, the management context variables are a series of mutually exclusive binary variables.

Table 20. Management context variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>University context 1</td>
<td>A binary variable indicating if the center lists on its Web site ties to or affiliation with a single academic department</td>
<td>Web, phone, email</td>
</tr>
<tr>
<td>University context 2</td>
<td>A binary variable indicating if the center lists on its Web site ties to or affiliation with a college or school that oversees multiple academic departments (and sometimes multiple centers).</td>
<td>Web, phone, email</td>
</tr>
<tr>
<td>University context 3</td>
<td>A binary variable indicating if the center lists on its Web site ties to or affiliation with a larger university research center or institute or laboratory.</td>
<td>Web, phone, email</td>
</tr>
<tr>
<td>University context 4</td>
<td>A binary variable</td>
<td>Web, phone, email</td>
</tr>
</tbody>
</table>
indicating if the center lists on its Web site ties no affiliation to any other academic units at a university but still resides on a university campus.

| University context 5 | A binary variable indicating if the center indicates on its Web site that it is not a university based center or if it is a university based center but does not reside on the university’s campus. | Web, phone, email |

To ensure valid coding of a center’s “university context,” there are a number of information sources. On any Web site there are a number of ways to find out how a center is situated organizationally:

- The home page may simply state the center’s location (e.g., “The Center for Quality Growth is located at Technology Square on Georgia Tech’s downtown Atlanta campus…”).
- Check the “history” component of the Web site
- Check the “directions” component of the Web site
- Check the “contact us” component of the Web site
- Download any brochures that may have location or contact or historical information
- If you suspect that a center is affiliated with another academic unit but are uncertain, find that academic unit’s Web site to cross check the affiliation

In most cases one of these options rendered obvious the other academic units to which a center has ties. In cases when none of the options “work,” the data goes uncoded as
missing pending a phone call or email to center staff or faculty. In cases where there is no contact information, the data remains un-coded as missing.

In the analysis in Chapter 8, the Management Context 4 and Management Context 5 variables were combined into a single “standalone” binary variable, due to the small number of centers qualifying for the criteria of the former variable.

**Multidisciplinarity and size**

A center’s count of the disciplines represented by its faculty membership and of the total number of academic researchers who are listed as center faculty were compiled from a series of count variables.

Table 21. Multidisciplinarity and size

<table>
<thead>
<tr>
<th>Preliminary name</th>
<th>Description</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity biologists</td>
<td>A count variable indicating the number of biologists included in a center’s faculty membership</td>
<td>Web, phone</td>
</tr>
<tr>
<td>Quantity environmental life scientists</td>
<td>A count variable indicating the number of environmental life scientists included in a center’s faculty membership</td>
<td>Web, phone</td>
</tr>
<tr>
<td>Quantity health scientists</td>
<td>A count variable indicating the number of health scientists included in a center’s faculty membership</td>
<td>Web, phone</td>
</tr>
<tr>
<td>Quantity computer scientists</td>
<td>A count variable indicating the number of computer scientists included in a center’s faculty membership</td>
<td>Web, phone</td>
</tr>
<tr>
<td>Quantity mathematicians</td>
<td>A count variable indicating the number of mathematicians included in a center’s faculty</td>
<td>Web, phone</td>
</tr>
<tr>
<td>Membership Count Variable Description</td>
<td>Web, phone</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Quantity physicists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of physicists included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity earth and atmospheric scientists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of earth and atmospheric scientists included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity chemists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of chemists included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity agriculture scientists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of agriculture scientists included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity social scientists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of social scientists included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of chemical engineers included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of mechanical engineers included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity electrical engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of electrical engineers included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity materials engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A count variable indicating the number of materials engineers included in a center’s faculty membership</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The coder usually consulted the “faculty” section of a center’s Web page and simply counted the number of scientists listed for each discipline. The coder counted the discipline in which the scientist received his or her doctorate degree. If the coder could not determine what discipline a scientist received her doctorate in (after searching the center Web site, academic department Web site, and online CV), the coder used the academic department in which the faculty member had an appointment as the discipline for the scientist. To ensure that these were coded validly, the coder used the National Science Foundation’s discipline categories (REF) to determine, for instance, whether a biochemist was classified as a biologist or as a chemist.

A “size” variable counting the number of academic researchers that a center claims as faculty was created from these count variables by simply adding them together. To create a count variable for the number of disciplines represented by a center’s faculty membership, I created a binary variable for each of the count variables indicating whether or not the discipline was represented by at least one center scientist. After creating these binary variables, I created a “multidisciplinary” variable that is the sum of the binary variables.

**Industry relations and programmatic affiliations**

The following variables were coded to indicate a center’s external relations with industry and programmatic affiliations, if any.
Table 22. Industry relations and programmatic affiliations

<table>
<thead>
<tr>
<th>Preliminary name</th>
<th>Description</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry relations</td>
<td>A binary variable indicating if the center lists on its Web site industry partners or an industrial advisory board</td>
<td>Web</td>
</tr>
<tr>
<td>NSF ERC</td>
<td>A binary variable indicating if the center is part of the NSF ERC program.</td>
<td>Web</td>
</tr>
<tr>
<td>NSF STC</td>
<td>A binary variable indicating if the center is part of the NSF STC program.</td>
<td>Web</td>
</tr>
<tr>
<td>NSF IUCRC</td>
<td>A binary variable indicating if the center is part of the NSF IUCRC program.</td>
<td>Web</td>
</tr>
<tr>
<td>NSF MRSEC</td>
<td>A binary variable indicating if the center is part of the NSF MRSEC program.</td>
<td>Web</td>
</tr>
<tr>
<td>NSF OTHER</td>
<td>A binary variable indicating if the center is part of a an NSF program other than those listed above.</td>
<td>Web</td>
</tr>
<tr>
<td>NON NSF</td>
<td>A binary variable indicating if the center is part of a centers program that is not one of the NSF centers programs. These may included DOD, DARPA, NIH, and DOE centers, as well as state centers of excellence.</td>
<td>Web</td>
</tr>
</tbody>
</table>

The coder consulted the “membership” or “industry ties” sections of a center’s Web site to determine if the center has industry partners. In more cases than not, the Web sites had tabs entitled “industry partners” or “industry advisory board,” or something comparable.
For the center’s programmatic affiliations, the coder consulted the center’s home page and when possible cross checked the affiliation with the centers program Web site.

In the analysis in Chapter 8, all of the NSF binary variables were combined into a larger “NSF centers program” binary variable.

**Coder reliability**

Neither the data coding nor the reliability checks are finished for this data set. However, all that can be coded from center Web sites has been coded, and this data has undergone preliminary reliability checks. Center data has been coded for about four hundred of the 499 Survey respondents\(^75\) indicating center affiliation, for the centers that have adequately informative Web sites. The remaining twenty percent or so of the data must be collected via phone or email, for those centers with Web sites that do not contain the information required to code the above listed variables. For this section “the coder” is a reference to an undergraduate research assistant who worked on this project.

**Management context variables**

The binary variables indicating the center’s affiliation with other units in the university were initially coded by an undergraduate assistant. Despite prolonged training in determining whether a center affiliates with an academic department, a college or school that oversees academic departments, another center or institute or laboratory, or whether the center is a “standalone” but university based center or is off campus or not university based, the undergraduate coder was unable to figure it out. After initial

\(^{75}\) This number excludes 66 Survey respondents from HBCUs and EPSCoR universities, which have been excluded from this study (see Appendix above).
reliability checks between the coder and myself, the correlation was only .65. Accordingly, I recoded all of the management context variables. Though these are quite easy to figure out and code accurately, this is apparently not the case for the coder who lacks institutional knowledge of university research centers and of other academic units. Required still is another coder to check the reliability of my own coding who has comparable institutional knowledge of centers and universities more generally.

**Multidisciplinarity and size**

The coder encountered few problems when coding the faculty and discipline count variables, at least when the center Web site had full faculty lists. For these variables both the coder and myself counted the number of academic scientists from each of the NSF discipline classifications. After a reliability check, the correlation between the coder and myself was .87. The reliability check for the count variable indicating the number of disciplines represented by a center’s faculty (the above “multidisciplinarity” variable), created twice – once using binaries from the coder’s discipline count variables and again using binaries from my own discipline count variables – is .92. The higher correlation rate is probably the result of the fact that the “multidisciplinarity” variable is the sum of binary variables coded “1” if a center has one or more scientists from a particular discipline. Accordingly, the accuracy of the discipline count variables do not matter as much as it matters whether the coder correctly identified that at least one center faculty member represented a particular discipline.

76 Certainly there are a slew of other tests for reliability, though many seem suited to continuous variables rather than binary variables.
Industry relations and programmatic affiliations

The coder and myself had no problems indicating whether a center had industry partners or an industry advisory board. The correlation for the coder and myself for this variable was .86. The correlation was even higher for the centers program variables, at .88, probably owing to center’s identifying in almost all cases on the home page of their Web sites their programmatic affiliation and also because of information available at the Web sites for the centers programs themselves.

Descriptive statistics

This table is a reiteration of the analysis in Chapter 7 (using the boxplots).

Table 23. Means and standard deviations for the centers level data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of academic scientists that centers claim as faculty</td>
<td>404</td>
<td>35.57921</td>
<td>39.57392</td>
</tr>
<tr>
<td>Total number of disciplines represented by center faculty</td>
<td>404</td>
<td>5.816832</td>
<td>3.392608</td>
</tr>
<tr>
<td>Binary indicating that a center affiliates with a college or school that oversees multiple academic departments</td>
<td>499</td>
<td>.2084168</td>
<td>.406584</td>
</tr>
<tr>
<td>Binary indicating that a center affiliates with no other academic units but resides on campus</td>
<td>499</td>
<td>.6673347</td>
<td>.4716406</td>
</tr>
<tr>
<td>Binary indicating that a center is off campus and/or not university based</td>
<td>499</td>
<td>.0400802</td>
<td>.1963441</td>
</tr>
<tr>
<td>Binary indicating if the center has industry partners or an industrial advisory board</td>
<td>444</td>
<td>.3648649</td>
<td>.4819353</td>
</tr>
<tr>
<td>Binary indicating if the center affiliates with an NSF centers program</td>
<td>461</td>
<td>.175705</td>
<td>.3809824</td>
</tr>
<tr>
<td>Binary indicating if the center affiliates with a centers program that is not an NSF</td>
<td>499</td>
<td>.2364729</td>
<td>.4253423</td>
</tr>
</tbody>
</table>
Current status

I am in the process of calling the centers that have Web sites with no faculty lists. There are about ninety left to code. Currently the data set is eighty percent completed.
The interview data

Sample

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

I did not select the interviewees at random insofar as the initial sampling set we derived from a list of more than 1,600 respondents to a national survey of university researchers (see Appendix above). From the 30 percent 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 National Science Foundation ERCs or STCs. I focused specifically on ERC and STC faculty members because each of these centers, being among the more complex and multi-faceted 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 and Boardman 2003 and 2004).

In semi-structured 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
type), 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), sixty percent were male, and about half were engineers with the rest being natural or life scientists.

**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 which we discuss below (e.g., Goode 1964, Box and Croton 1966). 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 (based on 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 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.

**Interview protocol**

Below is the semi-structured 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 and 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)
   
   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?

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 you 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 “NON-DEPARTMENT” 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
   Probes:
   - Please explain.
   - (ASK ONLY IF THEY MENTOR “NON-DEPARTMENT” 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
- 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 research projects 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
REFERENCES


Chiu (1998)


Feldman (1987)


