STRUCTURING TO ADVANCE SCIENCE:

STEM-CENTERED ORGANIZATIONAL INNOVATIONS

IN THE RESEARCH UNIVERSITY

by

JARRETT BENJAMIN WARSHAW

(Under the Direction of James C. Hearn)

ABSTRACT

As universities compete to advance science and secure external resources, many are changing the fundamental structure of their research cores. In knowledge production science, technology, engineering, and mathematics (STEM) fields have become increasingly interdisciplinary and lucrative, compelling adaptive institutions to develop continua of centers, institutes, schools, and departments for success in this arena. Yet little is known conceptually or empirically about these emerging organizational forms. This thesis draws on institutional theory, resource dependence theory, and academic capitalism to illuminate the nature and parturition of STEM-centered organizational innovations (SOIs). SOIs are centers, institutes, schools, and departments new to their institutions between 2000 and 2014, formed in externally funded areas of research, and with campus access to medical programs. The theories inform the selection of four U.S. public research universities, with each institution representing a quadrant of innovation based on indicators of its institutionalization (high or low) and resource position (strengthened or threatened) in the Association of American Universities. Sampled SOIs from one institution constitute a case for comparison to SOIs (e.g., cases) at the other, three institutions. Within- and cross-case analyses suggest that: Institutionalization neither holds campuses "hostage" nor permits uncoordinated "drift," but seems to differentiate the normative and financial margins around which SOIs develop, are politicized, and compete to endure. SOIs have the potential to broaden their institutions' resource dependencies across a number of federal mission agencies, but appear largely to converge within the biomedical/NIH arena. Within the context of academic capitalism, SOIs appear to open disproportionate pathways for scientific specialists/experts, rather than managerial professionals, to formal and symbolic positions of administrative/financial authority. Overall, SOIs in this analysis are suggestive of a deepening "love affair" with science among the public, policy-makers, and social institutions, and they may serve to reaffirm but also facilitate an image of the scientist as ideal educated self. Implications for theory, institutional policy and practice, and future research are discussed.

INDEX WORDS: Organizations, change and adaptation, research policy, innovation, institutional theory, case-studies

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial

Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2016

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May 2016

ACKNOWLEDGMENTS

I am honored—and humbled—to have worked with Jim Hearn throughout my time at the Institute of Higher Education. His approach to research, patient listening, and helpful guidance have shaped this thesis and will continue to anchor my growth as a scholar and professional. I am especially grateful to Jim, who with Austin Lacy first introduced me to the arena of research and development in science and technology. Thank you.

Sheila Slaughter's class on social theory, in Spring 2012, gave me the space, time, and readings through which to develop initial ideas for a dissertation. Our experience has inspired my research imagination. Her work ignites an ambitiousness, urgency, creativity, and precision of thought that I can only hope to glimpse in my own career. Conversations together about research policy, the AAU, academic structure, networks, and scientists can be heard in the pages of this thesis. They will stay with me, and continue to reappear in my mind and writing, for some time.

Erik Ness, as a teacher and researcher, has helped me learn about higher education policy and qualitative methods. His wisdom, generosity, stories, and humor have been so meaningful and important to this project and to our own collaborations. My deepest thanks to him for joining this dissertation committee—and for the late Friday afternoon meetings along the way.

There are many people who directly and indirectly have supported this work. Bill McDonald has been an especially important mentor, colleague, and friend. Kathleen deMarrais gave incredibly helpful feedback on an earlier version of the research design for this project. Joe Hermanowicz helped me sharpen my thinking about academic scientists and organizations, reward systems, and professors. Joe Murray guided me through my master's thesis, and his commitment to generativity and continued mentorship pushed me forward yet again.

I could write an entire thesis to express my appreciation—my love—for my family. Thank you for listening, for advising, for supporting, for loving. I am grateful for you. The Drakes have offered great warmth, hospitality, and spirit, a source of rejuvenation and home. Anna: You have been here for all aspects of this thesis, from the overwhelming to the joyful. You are infinitely kind and patient, steadfast and inspiring, and resilient and loving. I am lucky and proud to be your partner for life.

I offer special thanks to Manuel González Canché for his help with R Code and Figure 5 in this thesis, to Dave Johnson for his research advice, and to Tim Cain and Brian Pusser each for helpful conversations about this project. I am incredibly grateful to the archivists and librarians who have assisted me with tracking down numerous boxes of documentary materials for this study. Seventy-five individuals took the time to speak me with and exchange e-mails about their experiences of science and academic structure. They have been generous in both their time and thoughtful comments. I humbly acknowledge them, for without their involvement this thesis would not be.

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CHAPTER 1

INTRODUCTION

As universities compete to advance science and secure external resources, many are changing the fundamental structure of their research cores. Science, technology, engineering, and mathematics (STEM) fields have become increasingly interdisciplinary and lucrative, compelling even the most elite institutions to "tinker" with existing organizational units and create new entities for success in this arena (Geiger & Sá, 2008, p. 162). There are a number of possibilities that adaptive institutions may pursue in STEM: continua of centers, institutes, schools, and departments. Each potential set suggests great variation within and across campuses, reflecting heterogeneity of scientific niches, funding sources, faculty interests, and institutional goals. For more than half a century we have wondered about the future of academic organization (e.g., Geiger, 1990; Hearn, 2007; Ikenberry & Friedman, 1972; Peterson, 1976; Rossi, 1964; Veysey, 1965) around which universities position for relevance as producers of knowledge (e.g., Crow & Dabars, 2015; Gumport, 2002; National Academies, 2005). The study of new, emerging structures in the research enterprise presents an opportunity to revisit a persistent, familiar call for inquiry, but also to contemporize change and adaptation in higher education and what it means for institutional viability.

This thesis aims to contribute conceptually and practically to understandings of one type of change in research universities: what I call STEM-centered organizational innovations (SOIs). For analytical purposes, SOIs are centers, institutes, schools, and departments formed in externally funded areas of research, and as innovations they are new to the institutions that adopt them.[1] The SOIs included in this thesis are "new" as they have formed between 2000 and 2014, a window of time chosen to ensure an adequate sample of the most recent SOIs to date. Additionally, the SOIs for study here are those that engage specific strands of science (e.g., nanotechnology, pharmaceuticals, biomedicine, computing, etc.), serve the research mission of their institutions, have access to medical schools on their campuses, and have clearly articulated goals, affiliated personnel (e.g., directors, faculty members, administrative staff, etc.), and, perhaps most importantly, capacity to receive and allocate money. Within these parameters, this thesis focuses on the nature and parturition of SOIs. It aims to assay what these emerging organizational forms are and the external and institutional influences that underpin them.

Any given center, institute, school, or department may itself have distinct roles and boundaries on its campus. Each may have as well an intriguing path to development (e.g., Capaldi, 2009; Ikenberry & Friedman, 1972; Jong, 2008; Stahler & Tash, 1994; Trow, 1999). Without doubt organizational structures emerge at different times and for reasons particular to their campus contexts (e.g., Sá & Oleksiyenko, 2011). Yet it has become increasingly important to study SOIs as continua—sets—of interrelated units.

To achieve adaptability and nimbleness, researchers and analysts suggest, universities have aimed to develop matrix organizational hierarchies (Bolman & Deal, 2007; Geiger & Sá, 2008; Hearn, 2007; National Academies, 2005; Sá, 2008). A matrix

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[1] Rogers (1983) defines an innovation as "an idea, practice, or object that is perceived as new by an individual or another unit of adoption…a new alternative or alternatives, with new means of solving problems" (p. xviii). SOIs are innovations as they are new developments on their respective campuses. Yet, as Rogers' perspective suggests, an innovation may not be new across all universities, but is such within its local context. See also Dill and Friedman (1979).

typically resembles a grid of organizational units whose relationships are crosscutting by way of vertical, horizontal, and orthogonal links. Yet organizational units may have informal, less visible relationships, making delineation of a matrix's boundaries unclear and somewhat arbitrary. Through formal and informal network-like ties that it may engender, a matrix can facilitate the flow of resources, knowledge-production, and faculty members across units within an institution and in exchanges with external organizations (e.g., government agencies, industry partners, intermediary/non-profit organizations, etc.). Its effectiveness remains elusive at best, but the matrix structure has nonetheless been a salient way in which universities can increase responsiveness to opportunities for funding and research. It may offer the *fluidity* and *continuity* of resources and personnel needed for "big," team-oriented science, in interdisciplinary and highly funded areas such as genomics, data-analytics, biotechnology, computers, and brain-mapping and human behavior. Indeed, the spread of various units within a matrix suggests institutional aims to calibrate risk and cost of investments in research to optimize knowledge-production.

The research literature on change and adaptation in higher education has illuminated environmental and institutional influences that shape academic structure. Yet amid heightening competition in STEM, this literature suggests several knowledge gaps. Given the range of alternatives for structural change on campuses, it remains unclear which specific SOIs universities are developing and around which particular scientific niches. We continue to lack as well understandings of how universities' external resource base influences innovations in the research core (e.g., innovation from resource strengthened or threatened positions). Moreover, we know little about how universities' standings within a field, of long-term prominence or recent entrance/ascendancy, interact with their resource-bases to shape their set of SOIs. And we have thus far missed opportunities to study structural innovation at the "ground level," focusing on administrators and faculty whose entwinement influences processes and institutionalization of change.

In light of these lacunae, which motivate this thesis, I provide next an overview of the importance and emergence of SOIs. Then I present the research questions and outline the empirical approach and organization of this thesis. By way of conclusion I anticipate questions that readers may have, while highlighting the study's potential significance and contributions.

STEM-centered organizational innovations—Their importance and emergence

As adaptive continua of emerging organizational forms, SOIs may help research universities establish fit with their environments. They can rebalance resource flows and dependencies to restore their and their institutions' equilibrium. Cameron's (1984, p. 123) oft-cited definition of organizational adaptation underscores why SOIs matter conceptually and practically:

> "Organizational adaptation" refers to modification and alterations in the organization or its components in order to adjust to change in the external environment. Its purpose is to restore equilibrium to an imbalanced condition. Adaptation generally refers to a process, not an event, whereby changes are instituted in organizations. Adaptation does not necessarily imply reactivity on the part of an organization (i.e., adaptation is not just waiting for the environment to change and then reacting to it) because proactive or anticipatory adaptation is possible as well. But the emphasis is definitely on responding to some discontinuity or lack of fit that arises between the organization and its environment.

As such a perspective suggests, organizational boundaries are fluid but do not necessarily open institutions to deterministic control from external environments (Gumport & Snydman, 2002; Gumport & Sporn, 1999; Peterson, 1998). SOIs, for instance, can be considered examples of strategic recourse to mediate outside influence and increase autonomy (Oliver, 1991).

The contribution to institution-environment equilibrium may underscore the general importance of SOIs. But questions remain about SOIs themselves (e.g., what they are precisely) and the salient external and institutional influences that allow SOIs to develop as they do. In this thesis, I suggest that the nature of variation of SOIs within and across universities may be due to (1) federal research and development (R&D) funding, (2) status/standing of universities in a field, and (3) campus-level dynamics. Federal R&D funding and status/standing of universities in a field together constitute *environmental* factors, and campus-level dynamics pertain to *internal* shifts in administrator-faculty roles and boundaries in light of external influences. To set the scope of this thesis, each of these three variables is discussed next.

Federal research and development (R&D) funding provides strong incentives for structural change in STEM in research universities. In 2014, the federal government allocated $31 billion in R&D to higher education, and 94% of the money came from five mission agencies: Department of Defense (DOD), Department of Energy (DOE), National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA), and National Science Foundation (NSF).[2] States, private industry, and non-

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[2] Based on data from 1990 to 2014, the median percent of funding by the top five mission agencies that fund R&D at colleges and universities was: 49% from NIH, 13% from

profit organizations fund R&D on campuses, but fractions each of what the federal government administers (Stephan, 2012). Federal R&D funding never covers the full cost of research, yet brings visibility and prestige to institutions and faculty members and subsidizes work that can lead to improved human health and well-being and national economic competitiveness (Berman, 2012). The funds are concentrated among the academic elite though fluctuate over time for some institutions within the select group (Geiger, 2004).

The felt or anticipated gain or loss of federal R&D funding can motivate organizational change, but so, too, may the status/standing of universities in their field environments. A field has been defined as "organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products" (DiMaggio & Powell, 1983, p. 148). According to such a perspective, a field *stabilizes* as organizations conform to shared understandings of how they ought to structure for legitimacy. While stability may not always be the norm (Fligstein & McAdam, 2012), fields are social spaces of taken-for-granted, shared understandings, "rules of the game," normative influences, and interdependent relationships.

In this thesis, I suggest that research universities vary in their positions—their degrees of institutionalization—in a field based on the number of years they have been members (e.g., age) and the level of competitive resources (e.g., federal R&D funding) they have captured over time. As Slaughter (2014) suggests, it can be difficult, if not also arbitrary, to determine where a field begins and ends. For analytical clarity, I view the

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DOE, 12% from NSF, 11% from DOD, and 9% from NASA. Also over the 25-year period, the five agencies funded 93% of all federal R&D to colleges and universities.

Association of American Universities (AAU) as a field of institutions. There, members have specific dates of entrance/ascendancy that mark arrival among some of the most prestigious institutions in the U.S. They also have long-term patterns of federal R&D funding that situate them, respectively, in relation to one another. What is more, the field-level rewards and sanctions regarding federal R&D funding are understood: its successful capture reifies membership, and its decline, as developments in recent years suggest, can lead to outright dismissal (Carey, 2014).

Universities are institutionalized in their own rights (Kraatz & Block, 2008), and campus-level factors may contribute to their continua of SOIs. Changes may be unplanned, as institutions drift toward the needs and expectations of external stakeholders (Selznick, 1957). Other changes may be strategic. Cameron (1983, 1984) suggests that in times of resource turbulence that can compromise legitimacy, organizations may push to uphold the relevance of longstanding commitments while seeking to innovate in new arenas. An institution's history may hold it back from change (Selznick, 1992), a "collective action problem" (Jepperson, 1991, p. 151) that guards core values and interests. But cultural notions of history belie politics. New units emerge, this thesis suggests, when sponsors fund them and/or claim social responsiveness (Stephan, 2012). In this space, administrators and faculty members often work together to form SOIs, mixing financial and political resources to enact change. Together they help SOIs emerge—and remain viable.

Research questions and overview

Formally stated, three research questions orient this thesis:

(1) What is the nature of variation of STEM organizational innovations (SOIs) among research universities?

(2) How does the external environment influence the emergence of SOIs?

(3) How does the institutional context influence the emergence of SOIs?

For research question one (RQ1), "nature of variation" refers to continua of new STEM units within and across research universities. RQ1 offers an opportunity to assay structures and disciplines a particular institution has pursued—and compare them among universities. For research question two (RQ2), "external environment" means federal R&D funding (e.g., resource patterns for institutions over time) and field-related (e.g., degree of institutionalization) effects on the parturition of SOIs. Research question three (RQ3) asks about "institutional context," which refers to processes and drivers of adaptation within universities: history, politics, and people. It offers an opportunity to study the *locus of action*, the roles and influences of administrators and faculty members whose relationships and resources may underscore change on their campuses.

Conceptually, three theories offer explanations for the nature and parturition of SOIs: institutional theory, resource dependence theory, and academic capitalism. To summarize each: Institutional theory suggests that organizations become institutions when they are infused with value and meaning beyond their technical efficiency, drifting then stabilizing structures toward normative expectations and resources of stakeholders. Resource dependence theory explains the differentiation of organizational structure to help institutions increase autonomy and managerial discretion by way of spreading reliance on funding across numerous sponsors. Academic capitalism accounts for universities' quests for external resources that can prompt structural and behavioral recourse to markets and erode orientation toward the public good (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004; Slaughter, 2014).

The theories differ in their explanations of structural adaptation, but share three main assumptions. They assume an open systems perspective in which institutions have permeable boundaries; organizational structure mediates institutions' external relationships; and resource allocations indicate priorities, values, commitments, and goals. Academic capitalism has offered strong analytical purchase in this arena over the years, but may make some claims about institutions that are stronger than available empirical evidence (e.g., Bozeman & Boardman, 2013; Mendoza, 2012). In this way, the three theories work together to suggest how universities' longstanding histories and resource dependencies can shape strategic change (e.g., Kraatz & Block, 2008; Morphew, 2009; Oliver, 1991) and degrees of integration of and/or resistance to academic capitalism.

The theoretical framework informs an empirical approach. It suggests, as the focal point of this thesis, the grouping of AAU institutions into *quadrants of innovation* by dimensions of institutionalization and resource position. To elaborate, the universities can fall into (1) *high* or *low* institutionalization based on length of membership and level of federal R&D funding and (2) *strengthened* or *threatened* resource positions based on fluctuation (e.g., percentage change) of federal R&D funding. The quadrants are:

- Quadrant I: High Institutionalization/Resource Strengthened
- Quadrant II: High Institutionalization/Resource Threatened

- Quadrant III: Low Institutionalization/Resource Threatened
- Quadrant IV: Low Institutionalization/Resource Strengthened

For a relatively clean approach to situating the nature and parturition of SOIs in context, the public AAUs are considered in this thesis. That way, by accounting for institutional control (e.g., public and private status), the resulting analysis may indicate the extent to which institutionalization and resource position influences SOIs.[3] Within each of four institutions, situated in its quadrant of innovation, SOIs are then sampled. The SOIs at one university are a case for comparison across SOIs (e.g., cases) at three other universities. As theoretically informed, this thesis constitutes a multiple case study.

In the next chapter I discuss the research literatures that motivate this thesis. I address extant literatures on emerging organizational forms in research universities, federal research policy and field environments that contextualize and contribute to organizational change, and strategy and planning, at the institutional-level, which also account for academic structure. Chapter 3 provides a guiding theoretical framework. There, I draw on institutional theory, resource dependence, and academic capitalism to build a conceptual model that explains the nature and emergence of SOIs. Chapter 4 reiterates the three core research questions and outlines the empirical approach for the analysis. Chapter 5 presents case summaries of the sampled universities and their SOIs, followed by cross-case analyses in Chapter 6. By way of conclusion, in Chapter 7, I discuss the implications of the study findings for theory, institutional policy and practice, and future research.

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[3] Though not necessarily the central analytical aim, this thesis may also present evidence of organizational change beyond elite private institutions that tend to dominate the empirical literature (e.g., Colyvas & Powell, 2006; Etzkowitz, 2002; Geiger & Sá, 2008; Leslie, 1993; Lowen, 1997; Slaughter, 2014).

Significance and contributions

A note of caution is required before proceeding. As Hearn (2007) and Perrow (1986) each have observed, researchers and analysts interested in change and adaptation tend to focus on organizations—and fields—where change and adaptation is likely found. I have made all choices about which institutions and SOIs to study, possibly swaying the research toward dynamic campuses and precluding less actively changing, more openly resistant institutions. Such criticism notwithstanding, we have entered an era in higher education when institutions across all sectors, from research universities to liberal arts colleges to community colleges, are adapting. Certainly there is variation in how *aggressive* individual institutions, and indeed sectors, are in pursuing initiatives for strategic change (Brewer & Tierney, 2011; Christensen & Eyring, 2011; Selingo, 2013). Yet we are hard-pressed today to find complete stability or outright defiance of pressures to transform and innovate (Brint, 2005; Crow & Dabars, 2015; Jaquette, 2013).

The structural-functionalist angle from which institutional theorists approach research of organizations may be problematic for some readers. As such a perspective suggests, structure explains function and vice-versa. Critical theory could be better suited to address questions about power, hegemony, and entwinement of polity, economics, and social institutions (Gumport, 1991a,b; Slaughter, 1990). Academic capitalism (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004, Slaughter, 2014) expands the analytical purchase of this thesis: it describes motives and forms of organizational change but in sharpening our awareness provides mechanisms by which to challenge and critique the interests—and people—who shape and in turn can stratify institutions.

Research universities are complex organizations and change in many disciplines and fields (Gumport & Jennings, 2002). Readers may note that this thesis does not consider developments in the arts, humanities, and social sciences. These fields and disciplines are increasingly marginalized in external and institutional funding and thus compelling of research on forms of stratification (Slaughter, 2014; Taylor, Cantwell, & Slaughter, 2013). What is more, elite institutions are changing but those in other tiers are also pursuing adaptation (Brint, 2005; Jaquette, 2013), though the AAU institutions in general, and the elites among them in particular, are widely emulated (Rhoades, 2000; Slaughter & Rhoades, 2004). And SOIs, if defined more broadly than what I have proposed, could entail educational and graduate training-focused structural units on campuses that aim to improve the national STEM workforce.

Finally, this thesis does not address the issue of whether SOIs, ultimately, succeed or fail. The main focus here centers on the *nature* and *parturition* of emerging organizational forms within and across research universities. Such a perspective may preclude opportunities to evaluate whether particular types of SOIs are more effective than others and which specific sets or arrangements of SOIs achieve goals of increasing federal R&D funding that might not have otherwise been procured. For instance, do centers and institutes receive more federal R&D funding than schools and departments? Which combination of SOIs, of centers, institutes, schools, and departments, is associated with the greatest gains in a university's federal R&D funding and status/standing? These questions fall beyond the scope of this thesis. To be sure, *claims* of success are of analytical interest in this thesis, for they may tell us some about the nature and developmental processes of SOIs (e.g., what it takes to emerge and seek to survive). Yet analyses of outcomes associated with SOIs are for future work in this arena.

Limitations notwithstanding, there are several contributions that this thesis may make. It aims to contribute to the growing literature on organizational change and adaptation in higher education in general and to innovation on campuses in particular. In addition, it may shed some light on innovation as mechanism for *fluidity* and *continuity*: the leveraging of organizational structure for ongoing exchanges of research, money, and people throughout an institution and in external relationships with funding sponsors and stakeholders. Relatedly, this thesis may highlight roles of *quadrants of innovation* in shaping the structural and financial possibilities of new, emerging organizational forms. But this thesis can also help us understand innovation at the "ground level," wherein the *scientist-as-administrator* may be increasingly prevalent—and prominent—in contemporary dynamics of strategic change on campuses. From its potential core conceptual and empirical developments, this thesis may point toward areas of institutional policy and practice by which leaders and faculty members may steward institutions to balance pursuits of science, money, and values.

CHAPTER 2

REVIEW OF LITERATURE

In efforts to advance science and secure external resources, many universities are developing new organizational forms to strengthen their research cores. Continua of structural possibilities exist for institutions that adapt to compete in science, technology, engineering, and mathematics (STEM). Within and across institutions we may expect to find a range of centers, institutes, schools, and departments that position around any number of scientific niches, funding sponsors, faculty initiatives, and institutional goals. This thesis focuses on one particular type of change: what I call STEM-centered organizational innovations (SOIs). For analytical purposes, SOIs are centers, institutes, schools, and departments formed in externally funded areas of research, and as innovations they are new to institutions that adopt them. Examining what they are, how they vary, and how they form offers opportunities to study contemporary dynamics of change and adaptation in higher education. This chapter presents a review of extant literatures to contextualize the *nature* and *parturition* of SOIs at research universities.

In the first section, I address prior research on centers, institutes, interdisciplinary schools, and academic departments in STEM. The discussion aims to delineate SOIs and build initial understandings of them as inter-related developments on their respective campuses. I divide the second section—environmental influences on the emergence of SOIs—into two parts. First, I discuss historical developments in federal research policy to illuminate governmental roles and money in incentivizing structural change of universities. Second, I discuss the literature on the Association of American Universities (AAU) to suggest that the AAU functions as a field in which its elite members pursue strategic initiatives for federal research and development (R&D) funding and status/standing. In the third section, I discuss the literatures on campus-level strategy, planning, and academic structure respectively to highlight effects of institutional politics and resources on organizational change.

Taken together, the sections establish the empirical direction of this thesis. They address the nature of variation of SOIs within and across elite research universities, the influence of the external environment on the emergence of SOIs, and the campus-level dynamics that can prompt structural adaptation. Yet, as I conclude in this chapter's summary, the literatures most central to this thesis suggest a number of knowledge gaps. Of these lacunae, four are especially prominent:

- It remains unclear which specific SOIs universities develop and around which particular niches in STEM.
- We continue to lack understandings of how universities' historical patterns of federal research funding influences innovations in the research core (e.g., innovation from a position of resource strengthened or threatened.).
- Moreover, we know little about how universities' status/standings within a field, of long-term prominence or recent ascendancy, interact with their resource-bases to shape their set of SOIs.
- And we have thus far missed opportunities to study organizational innovation in higher education at the "ground level," by focusing on administrators and faculty who together influence and institutionalize change.

Nature of variation of emerging organizational forms

SOIs encompass centers, institutes, schools, and departments. In this section I review extant literatures to indicate how each of these organizational forms, which together constitute SOIs, can vary in structure, origins, and operations. I then build from the literature initial understandings of ways in which SOIs could fit within matrices of interacting units and subunits on their respective campuses. Researchers and analysts suggest institutional inclinations toward and the possible benefits of matrices within campus administrative hierarchies (Bolman & Deal, 2008; Geiger & Sá, 2008; Hearn, 2007; National Academies, 2005; Sá, 2008), but have not necessarily studied empirically the continua of organizational structures within and across institutions. A matrix typically resembles a grid of organizational units with vertical, horizontal, and orthogonal links by which to facilitate crosscutting flows of research, money, and personnel. Current literatures on centers, institutes, schools, and departments in STEM help us appreciate the variation—the creativity—of structural adaptations on campuses. To tie together these literatures, in the conclusion of this section, may shed some light on efforts of universities to establish both *fluidity* and *continuity* of research, money, and faculty members to advance science.

Centers and institutes have developed as part of broad movements at universities to expand the research enterprise (Gumport, 1991a). As organized research units (ORUs), they can be viewed as occupying a somewhat peripheral space in comparison to the academic core: the heartland of schools and departments. Given their locations, both literal and symbolic, at the margins of campuses, centers and institutes have long-been considered to "do what departments cannot do: to operate in interdisciplinary, applied, or capital-intensive areas in response to social demands for new knowledge" (Geiger, 1990, p. 17).[4] In this way centers and institutes tend to be associated with adaptability, more open and permeable to external stakeholders than campus-oriented schools and departments. When centers and institutes pursue research initiatives perceived as antithetical to educational missions of their home institutions, their operating from the periphery can protect self-interests and also buffer campuses from goal displacement.

Indeed, centers and institutes often receive criticism as research units that serve money-making and market interests. Such a perspective suggests structural adaptation toward "a kind of academic capitalism, an orientation toward profit rather than education" (Ikenberry & Friedman, 1972, p. 97; see also Slaughter & Leslie, 1997). From expansion of research, centers and institutes may generate additional revenue from federal and state grants and private industry (Cohen, Florida, & Goe, 1994). The exchange of money for research raises concerns, among critics, about erosion of disinterestedness that has often given legitimacy to academe as a social institution and protected its well-spring of knowledge (Kenney, 1986).

Some centers and institutes intensify role strain among affiliated faculty members who also hold departmental appointments. Their research commitments can stretch thin involvement in teaching and education (Boardman & Bozeman, 2007). Government funding of centers and institutes further incentivize research collaboration of faculty members and industry partners (Boardman, 2009), underscoring broad institutional interests in economic goals (Cohen et al., 1994). Recent evidence from a national survey

[4] Rossi (1964) provides a helpful discussion of an organized research unit in the social sciences, an organizational change, he suggests, rooted in the emergence of large-scale research to meet societal needs.

of center and institute directors suggests centers and institutes contribute to teaching and education (Bozeman & Boardman, 2013), though their emphasis in early iterations (Rossi, 1964) and today (Sá, 2008) pertains to extension of academic research. Despite longstanding concerns about them, centers and institutes are becoming increasingly central organizational forms. They do not displace the core of schools and departments; however, institutional competitiveness in science—and relevance as organizations that produce knowledge—may depend on them (Geiger & Sá, 2008).[5]

As centers and institutes are innovative organizational forms, they can be difficult to operationalize. Geiger (1990) suggests that centers and institutes differ from each other in their respective orientations toward external stakeholders. Centers, he observes, tend to have broad missions and scopes of activities and *some* connectedness to government and industry sponsors, while institutes often have narrowly defined missions and scopes of activities and *close* connections with government and industry sponsors. But as other observers indicate, the nouns "centers" and "institutes" are interchangeable (Ikenberry & Friedman, 1972). Whether they are called "centers" or "institutes," ORUs can have comparable characteristics in scale of activities, staff, goals, budgets, and external orientations (Stahler & Tash, 1994).

Prior groupings of centers and institutes by type suggest three categories into which these organizational forms may fit.[6] *Standard* centers and institutes resemble bureaucratic organizations. They have administrative hierarchy, research equipment,

[5] Schools and departments, as addressed in this chapter, are teaching-focused yet analogous to centers and institutes permeable to the political economy (Slaughter & Rhoades, 2004).
[6] Ikenberry & Friedman (1972) have advanced the taxonomy of centers and institutes in higher education, based on Becker and Gordon (1966). Stahler and Tash (1994) have employed the taxonomy as well in their study of university centers and institutes.

stable goals, and resources that together justify their physical accommodations on campuses. *Adaptive* centers and institutes are known for shifting their staffing arrangements, activities, and goals based on external opportunities. In some cases adaptive units may dissolve when funding for them ends and/or when affiliate faculty conclude projects. Sometimes they reemerge anew to position around different scientific problems, funding sources, and personnel. Because they are protean, meant to assemble and reassemble, they do not usually have their own facilities or designated spaces on campuses. More elusive than their standard and adaptive counterparts, *shadow* centers and institutes may exist only in the minds of faculty members. Other shadow centers and institutes may be small, one-time collaborations, signs or plaques on doors of faculty members' offices, and/or have "paper" status by way of insignias or logos in letterheads.

Within a contemporary context, universities increasingly pursue *virtual* centers and institutes that blend adaptive and shadow forms. These typically have a director or associate director, access to facilities and equipment, and official websites for promotion (e.g., the modern form of shadow, "paper" organizations), but do not have unique physical locations on campus per se. Not quite *adaptive*, virtual centers and institutes may have stable research programs, affiliated personnel, and budgets. As Bozeman and Boardman (2013) observe, more university-funded centers and institutes are virtual than state- or federal-backed centers and institutes, suggesting "relatively modest investment in resources based on existing capabilities rather than new initiatives" (p. 100). Virtual centers and institutes may not have their own facilities or equipment, yet can minimize start-up costs for operations/activities and open additional opportunities for external research funding.

Let us consider how each type of center and institute fits together to serve institutional interests. Standard centers and institutes may require the biggest front-end investments and have the highest costs for maintenance and upkeep of equipment and facilities and personnel. Adaptive, shadow, and virtual units vary in costs and thus guard institutions and sponsors from some financial risk. Standard centers are not necessarily effective (Feller, Ailes, & Roessner, 2002; Florida et al., 1994), and their adaptive, shadow, and virtual counterparts can boost research activity without long-term resource commitments.

As one example, the National Science Foundation's (NSF) Industry/University Collaborative Research Center (I/UCRC) initiative seed-funds centers at universities. Industry partners pay membership fees to finance center operations and gain access to university-based technologies, faculty, and intellectual property. Institutions invest resources as well. The approach aims to enhance *fluidity* of inter-organizational boundaries to balance funding across stakeholders, but institutions tend to cover disproportionate shares of costs, and *continuity* of funding for research remains problematic. While most centers and institutes form organically from independent actions of individual and groups of faculty members, they can be situated in matrices of benefit to themselves and their home institutions.

The position of centers and institutes within the campus administrative hierarchy suggests matrices that balance risk and investments. Consider a scenario on one single campus. Some centers and institutes receive hard-money lines from central administration and report directly to the provost and/or to their soft-money external funding agency (e.g., mission agency, state office, industry partner, etc.). Other centers and institutes on campus may fall within the oversight and budgets of colleges and schools.[7] They may receive money for start-up costs and portions of their operating budgets, with directors reporting to college deans and/or school directors. Another set of centers and institutes may have departmental affiliations, from which they receive political support, though not always money, from chairs. Among virtual centers and institutes, they may on websites suggest departmental links but report only to their directors and associate directors. In these cases, there can be minimal administrative oversight within the university and relatively low or no institutional funding for them. Campus leaders—provosts, deans, directors, and chairs—may thus concentrate financial investment, time, and supervision in centers and institutes likely to have wide-spread influence across their institutions. They can calibrate involvement and money in other entities still important for institutional visibility and goals but perhaps less expansive than hard-money line counterparts in reach, scope, and impact.

Despite differing locations within campus administrative hierarchies, centers and institutes continue to serve initiatives to advance science and attract resources. Their origins reveal the level of importance they have on campuses and to external sponsors. The Center for Materials Research (CMR) at Stanford University provides an example.

In 1961, Leslie (1993) notes, the then-newly forming CMR contracted with the Department of Defense's Advanced Research Projects Agency (DARPA). By 1965, the

[7] In nanotechnology, for instance, centers and institutes are a source of seed-funding for other centers and institutes in areas of further specialization (e.g., biomedicine, sensors, computing hardware, etc.). For these arrangements, directors of newer centers and institutes may report to the directors of the overseeing centers and institutes. College deans in related areas, such as engineering, may also invest resources in both sets of centers and institutes and have advisory roles. Thus we can see another layer of complexity in understanding variation of SOIs and a variety of arrangements within the administrative hierarchy of universities.

center itself was built on the Palo Alto campus in part from the four-year $2.6 million commitment from DARPA and $1.5 million from Jack McCullough, co-founder of the San Francisco Bay area's oldest electronics firms Eitel-McCullough. The mix of federal, industry, and institutional support provided for CMR's $1 million annual operating budget, funding at that time cutting-edge facilities for crystal synthesis and preparation, X-ray analysis, thin-film preparation, and electron microscopy, among others. Money not spent on technology went to recruit new faculty who were expected to compete for independent contracts to generate additional external funding.[8] At Stanford, as elsewhere, federal funding codified new organizational structures, attracted top faculty in emerging, interdisciplinary fields, and subsidized technology to give competitive edge and prestige to the home institution (see also Lowen, 1997).

Robust funding for nationally recognized centers and institutes does not always guarantee successful initiatives. As Geiger and Sá (2008) observe, the State University of New York at Albany (SUNY Albany) developed in 2004 the nation's first College of Nanoscale Science and Engineering (CNSE). SUNY Albany's federal R&D funding pales in comparison to elite public and private research institutions, but the College's resource infrastructure entails $3 billion in state ($500 million) and industry funding ($2.5 billion). Analogous to CMR's strategy at Stanford in the 1960s, CNSE at SUNY Albany intends to leverage its resources to accrue "toys" unrivaled in higher education

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[8] The contracting of classified defense research in the era of the Cold War to Stanford University and the Massachusetts Institute of Technology (MIT) prompted backlash. Leslie (1993) notes that MIT earned the nickname "Pentagon East" and "Pentagon on the Charles" (p. 235). At both Stanford and MIT, faculty and students protested the military's reach on their campuses, outraged that military-industrial interests and money were polluting the values of educational institutions. Indeed, DOD funding led to organizational innovations in STEM at these elite universities, but, as Leslie warns, infused within them its own militaristic agenda.

for research and also recruitment of industry partners, faculty, and students. Despite its technological arsenal and success in recruiting semi-conductor consortium SEMATECH to the region, “to date, the top nanoscale scientists and students appear to favor academic reputation over Albany’s toys” (Geiger & Sá, 2008, p. 175).

Elite private universities have endowment wealth that advantages them over public research universities in developing centers and institutes. In the early 2000s, according to Geiger and Sá (2008), Duke University invested $55 million to form the Institute for Genome Sciences and Policy that in research and educational activities included biomedicine, engineering, health economics and policy, statistics, and information science. At the time of its founding the Institute was intended to become self-sustaining, thus giving central administration subsequent budget cycles to put money toward other new ventures and organizational forms on campus. Nonetheless, public research universities have size and scale dimensions unmatched among private institutions (Brint, 2005, 2007). Expansiveness of programs and experts across fields and disciplines offers additional opportunities for faculty-driven formation of centers and institutes. And state funding targeted to research initiatives, which have explicit public benefits, may give, albeit selectively, shots to the research core for change and adaptation not otherwise realized (Berman, 2012).

Centers and institutes are prominent developments within the group of SOIs, but are not the only emerging organizational forms new to adaptive universities. A number of institutions have developed interdisciplinary schools and academic departments in targeted areas. Academic structure has typically been linked with expansion of the research function in higher education. Clark (1987) captures the perspective well:

> New subjects were born out of the more inclusive, established ones, which were becoming swollen from the ingestion of new material. In particular, new academic sciences issues from natural philosophy and natural history. As an academic subject, chemistry was in place by 1820, soon followed by astronomy, physics, and biology. (p. 27)
>
> After the middle of the century, at an accelerating pace, parturition continued. Biology delivered genetics and microbiology and then cross-fertilized with bordering sciences to produce biochemistry and biophysics. (p. 28)

Advancements in research may indeed lead to "revolutions" that alter assumptions, theories, methods, and techniques of fields (Kuhn, 2012). Such developments in knowledge production tend to lead to new departments on campuses, especially as emerging disciplines and fields spread and gain legitimacy globally by way of professional societies and associations (Drori et al., 2003; Schofer, 1999, 2003; Schofer & Meyer, 2005). That is, new schools and academic departments can codify around the professionalization of faculty members. Over time they tend to endure because of increasingly embedded curricula, budgets, and political support.

But some fields and disciplines have rather arbitrary boundaries, belying needs for academic units. In the 1990s, for instance, many universities restructured STEM departments. University of California – Berkeley underwent prominent structural change in biology in the late 1990s because its prior set of units had lost national status/standing, federal research funding, faculty caliber, and opportunities to tap into the emerging biotechnology arena (Jong, 2008; Trow, 1999). Indeed, one approach to reducing operating costs and opening boundaries for research, funding opportunities, and faculty recruitment entails the merging of departments into interdisciplinary schools.

At Arizona State University (ASU), campus leaders in the early 2000s formed 14 schools from restructuring of departments. The structural changes aimed to reduce costs from duplication and competition across graduate and undergraduate programs, while also seeking to foster interdisciplinary research. The School of Life Sciences provides an example:

> …in some of the units faculty members are organized into "faculties," not departments. For example, prior to the creation of the School of Life Sciences, there were separate departments for biology, plant biology, microbiology, and molecular and cellular biology. Now, the School of Life Sciences has the following faculties: biomedicine and biotechnology; cellular and molecular biosciences; evolution, ecology, and environmental science; genomics and evolution; and organismal, integrative, and systems biology. The objective was to form a structure that could be easily reorganized around big programs and engage in use-inspired research.
>
> Unlike departments, the faculties are designed to be flexible and respond to this evolving area of science…. (Capaldi, 2009, pp. 23-24).

As recent developments at ASU suggest, fluidity in organizational forms can meet student interests and accommodate and promote further the boundary-spanning of faculty research collaborations (Crow & Dabars, 2015). In STEM, the School of Life Sciences is but one of several new units that also includes the School of Sustainable Engineering and the Built Environment, the School of Electrical, Computer, and Energy Engineering, the School of Biological and Health Systems Engineering, and, among others, the School of Computing, Informatics, and Decision Systems Engineering. Analogous to centers and institutes, interdisciplinary schools can position faculty around new scientific areas of research and external funding sponsors.[9]

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[9] The fluidity of organizational boundaries in interdisciplinary schools suggests financial incentives for cross-collaborative research. Rather than losing-out on money from external grants, which could flow toward one department more than another, participating deans and directors and faculty of schools can gain from sharing and spreading incoming resources. Schools can open budgetary possibilities, compared to prior academic structures that tend to foster zero-sum games and limit cross-campus research initiatives.

Discerning readers may question whether interdisciplinary schools, comprised of existing and restructured academic departments, are *new* organizational innovations. Schools can develop from repurposed buildings and facilities, existing curricula from prior programs, and reassigned faculty members and administrators. But they tend to have new budgets, goals, activities, degree programs, and research agendas. Schools are innovations. They draw on prior strengths and resources to move beyond relics of traditional academic form.

The fourth section of this chapter focuses on academic departments. But clearly departments serve more than educational functions, and they fit within continua of research-focused SOIs on campuses. Indeed, departments remain the foundational units of universities. As Clark (1987) writes of higher education's transition from the second half of the nineteenth century to the second half of the twentieth century, "Strung between the dead and the living were institutional forms that refused to die" (p. 4).[10] Academic departments can close (Gumport, 1993; Slaughter, 1993b) but typically accrete over time (Gumport & Snydman, 2002; Hearn, 2007; Veysey, 1965). In STEM, external funding may form new academic departments and legitimize emerging fields for education and research (Gumport, 1991a).

Consider the rise of materials science in the Cold War era. "The [national] defense establishment," notes Leslie (1993, p. 213), "virtually created materials science as an academic discipline, funding all but a tiny fraction of American materials research

[10] Tierney (1993) suggests that new state universities may aspire to innovate in organizational form, preferring to move beyond academic departments as core organizing units, but succumb to state-system pressures to conform to the structure of predecessors. Bastedo (2007) builds on Tierney's work, finding that new state universities can innovate in core organizing structures when they have policy advocates (e.g., institutional entrepreneurs) who devote resources to protect them from influences to conform.

during the Cold War years." When physics departments receded from conducting defense research, wary from eroding too much autonomy during the Manhattan Project, their reticence helped materials scientists who prospered and organized into research units and, eventually, academic departments. Analogous to materials science, biomedical engineering departments developed in the U.S. due to external funding. As Stephan (2012, p. 119) observes,

> The Whitaker Foundation, for example, devoted its entire resources to transforming biomedical engineering from a barely recognized discipline into a firmly established field. During its 30 years of existence, the foundation gave away more than $800 million to help create departments of bioengineering at universities and provide support for graduate student training and faculty research.

The Whitaker Foundation from 1990 to 2006 spent all of its money on forming new bioengineering departments and then dissolved as an organization. Yet its genius in inspiring research and education at the intersections of medicine and engineering has proven lucrative for some institutions and faculty members. Biomedical engineering programs capture high-caliber pre-medical undergraduate students, but also attract researchers and scholars who position for federal grants from the primary federal funders of academic research: the National Institutes of Health and National Science Foundation.

Money is not the only catalyst of academic departments. The initial suppression but ultimate rise of women's studies departments has roots in the feminist social movement (Gumport, 1988). In STEM, the *money-making potential* of start-up, tuition, and research dollars and *social responsiveness* to emerging issues of national concern places academic departments as important developments within continua of SOIs.

Overall, SOIs can go in any number of structural and scientific directions. The great variety and variation of SOIs is what is perhaps most striking: no one has figured out how best to organize to advance science. But to compete many universities may entwine their respective SOIs within matrices. Here we see how SOIs, which can form in unplanned, organic ways, may inter-relate. As matrix forms of organizations suggest (Bolman & Deal, 2008; Geiger & Sá, 2008; Hearn, 2007, National Academies, 2005; Sá, 2008), centers and institutes cut across horizontal structures of schools and academic departments. Yet centers and institutes may have links to one another—not necessarily formal or vertical by way of reporting relationships but in *network affiliations*. Such arrangements between (1) centers and institutes and (2) centers and institutes and schools and departments can facilitate flows of research collaboration, money, and people, covering the spectrum of education, scientific niches, and funding sources. It remains unclear, though, what precisely drives the variation of SOIs within and across universities. In the next section, I focus on literatures pertaining to two strong environmental influences on universities in this arena: federal research policy and the Association of American Universities (AAU).

Environmental influences on emerging organizational forms

Federal research policy

The federal research policy system suggests accretion over time in growth of mission agencies. When the government recognizes new and evolving national needs (e.g., defense, aerospace competitiveness, post-war science, health, knowledge-economy initiatives, etc.), it can move to form an agency (Wilson, 1983) and by way of Congress repurpose funding within and across agencies (Slaughter & Rhoades, 1996). For example, after the terrorist attacks of September 11, 2001, the federal government created the Department of Homeland Security. The Homeland Security research budget is but a fraction of the Department of Defense's (DOD), but does fund applied academic research. Amid national fears over bioterrorism in the early 2000s, Congress and the National Institutes of Health also redirected funding toward studies of anthrax. Apart from congressional budgetary authority and the individual missions of the funding agencies, there has nonetheless been a lack of central, coordinating mechanism that manages and couples together the various agencies, from the DOD to NSF, NIH to the Office of Naval Research (ONR) (e.g., Gumport, 1991a, 2011).[11]

To have federal research policy and a system of mission agencies by which to allocate money assumes the importance of science and scientists in society. It suggests an inherent need for scientific research based on claims of science as authoritative, objective, and practical. As Greenberg (1999, 2001) observes, policy-makers tend to perceive science as advancing *certainties* about how to solve problems when, instead, science offers *probabilities* about the success of proposed solutions. In the politics of research policy, Greenberg elaborates, we may see a sort of *evangelism* emerge by which scientists themselves seek to "convert" the public to adopt faith and belief in the powers of their craft (see also Gieryn, 1983). Such a prominent positioning of scientific research in policy and funding can come from efforts of the scientific community (Kevles, 1978).

Indeed, it could be naïve to ignore the dynamics—politics and economics—of professionalization in explaining the development of research in STEM (e.g., Jencks &

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[11] The federal research policy and national higher education systems parallel one another. Decentralization, accretion, competition, and market-coordination underpins both of these arenas. The commonalities—and overlaps—in the structure of federal research policy and higher education can come with competitive benefits (Ben-David, 1992), which some observers suggest make for U.S. "predominance in science" (Geiger, 2004).

Riesman, 1964; Rudolph, 1990; Veysey, 1965) and the value of scientific research among federal policy-makers (Kleinman, 1995; Slaughter, 1993a). The scientific profession actively pursues resources for legitimacy (Gieryn, 1983; Gumport, 1991a,b; Hackett, 1990; Johnson, 2011; Slaughter & Rhoades, 2004). Scientists, as some suggest, have chosen research universities as their home (Wolfle, 1972), as academic institutions tend to offer autonomy in which to work, certify and guard intellectual and moral authority of professors, and provide access to institutional and external funding.

From their organizational affiliation scientists can entwine universities, industry, and government and foster ties through access to their research. In the late 19th Century and into the early 20th Century (circa 1920s), private industry, more than the federal government, invested in scientific research at universities (Geiger, 1986, 1988, 1993). Research—and science—has often been considered “sacred,” “pure,” and “value-free,” but to “tap the riches of science” for commercialization and markets can be profitable (Geiger & Sá, 2008). Industry outpaces academe in R&D funding and activity, yet to minimize costs and maximize benefits of discovery and innovation can and often do contract with universities. When, in the 19th Century, the federal government also turned to higher education to advance economic agendas, it began to formalize policy toward and roles in academic science.

The Morrill Land Grant Act of 1862 authorized selling federal lands to states for building colleges and universities. A stipulation indicated that these new, public institutions were to offer education in agriculture and the mechanic arts. Hence we see in *structural form* and *mission* the emergence of A&M institutions nationally. In 1890, the Hatch Act led to further structural and procedural change and adaptation in many of these emerging public universities, aiming to leverage science for society. The Hatch Act provided for experimental, agricultural stations at land-grant institutions, by which faculty members offered solutions to problems that farmers encountered. These stations served as platforms to affirm—and exchange with members of the public—expert knowledge of institutions and faculty members.

In both cases of the Morrill Land Grant and Hatch Acts, we see common themes and assumptions. We may detect entwinement of public research universities, the surrounding economy, and government/national interests. Positioned as holding expert knowledge, universities—and their scientists in particular—could be seen as central in government plans to transition the economy and workforce from agricultural to industrial and manufacturing-based. Indeed, the federal government seems to have utilized, early in the development of higher education, policy and resources (e.g., land and money) to leverage institutions and their faculty members to prepare the children of farmers for major urban centers and industrial careers. Moreover, we may interpret the assumptions of both Acts regarding the flow of information and knowledge of science: society comes to higher education with problems for which the work of scientists presents solutions. Scientists thus position themselves and their institutions as legitimate, as intellectual, moral authorities warranting financial support.

Interestingly, however, industry funded the majority of academic research into the early 20th Century (Geiger, 1988). States resourced public institutions, but it was not until World War I (WWI) and World War II (WWII) that the national government took increasingly active, deliberate roles in financing universities, science, and scientists. As Leslie (1993) suggests, WWI was the war of chemists (e.g., chemical weapons) and

WWII the war of physicists (e.g., the atomic bomb). Contributions to national defense positioned these scientists, their disciplines, and universities prominently in federal agendas and funding streams. Yet, Leslie maintains, the values (and money) of military imperialism may become embedded and reified within the social structures of higher education. Recall that, for this reason, some physics departments receded from defense-funded areas of research while new units in materials science, which actively sought such funding, were able to emerge and flourish.

The priorities of government, institutions, and academic scientists can diverge. Academic scientists and universities may lose control over research discoveries (Herken, 2000; see also Aviv, 2014). In the case of the atomic bomb in WWII, members of the academic scientific community acknowledged the human health and moral dangers of their creation. Chief scientists from the Manhattan Project sought to inform government officials about the sheer destructiveness of the atomic weapon—and what such weaponry augured physically and morally for victims and aggressors. Yet, as Herken suggests, the voice of scientists in "cardinal choices," in whether people lived or died, was ignored.[12]

Despite tension and conflict, by the 1940s, institutional leaders, scientists, and government officials moved to form post-war research policy. The World Wars had privileged research universities and select, elite scientists. Institutions continued to build research infrastructure and capacity to accommodate, but also influence, resource flows and exchanges with industry and government. But post-war realities suggested dips in external funding—and institutions themselves did not (and perhaps would not or were

[12] We may thus surmise why, structurally on campuses, centers and institutes in particular could be kept peripheral from the academic core. At "arm's length," institutions may adapt to contribute to national defense and position for research funding, but also distance themselves from some of the ethical implications of the work of scientists.

unable to) devote their own internal resources to sustaining the costly academic research enterprise. The utility of applied research seemed to obscure focus on basic research, which industry undertook but was somewhat socially (and economically) suboptimal without the involvement and investment of academic institutions.

Forming post-war research policy, the federal government confronted a series of questions. As Brooks (1968), Rivlin (1961), and Smith (1990) each have noted, policy-makers considered:

- Who should govern federal research policy?
- Should there be a central office, within the federal government, to coordinate the various agencies and policy and funding directions?
- How much funding should go to basic versus applied research—and in which fields and disciplines?
- Should research universities receive funding geared toward building institutional capacity, funding that supplements money for research?
- By how much should research funding to universities increase each year?
- Who should decide which projects, institutions, and scientists to fund?
- Should funding be spread across institutions and states or concentrated at elite research universities with elite scientists?

These questions framed the debates between Vannevar Bush of MIT and West Virginia's Sen. Kilgore, whose perspectives informed federal research policy from the 1940s forward. Bush, an MIT scientist and vice president, was a scientific advisor for the government and recommended in 1945 that it crate an agency to fund basic research. He envisioned funding being located primarily at elite research universities (such as MIT), institutions with eminent researchers and unrivaled scientific infrastructure. Somewhat lyrical and visionary, Bush proposed the need for continuous financial support to sustain science in the "endless frontier" of discovery and innovation.[13]

In opposition to Bush was Sen. Kilgore's proposal to fund applied rather than basic research and spread funds across institutions and states democratically. It was Bush's proposal and advocacy (and perhaps authority as elite scientist from MIT) that led to the creation in 1950 of the National Science Foundation (NSF).[14] The NSF was charged with funding, analogous to the Office of Naval Research, basic research conducted largely at academic universities.

For coordination of funding agencies, the federal government has maintained decentralization except for budgetary allocations from Congress. The missions of the agencies direct them, and use and proliferation of multiple agencies, though seemingly uncoordinated, helps to cover a range of scientific areas and protect against some duplication of funding for projects. Though some have argued for steady increases, by as much as 15% per year, in research and institutional funding for universities (e.g., Brooks,

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[13] "Endless frontier," critics note, suggests political and economic motives of the scientific community. On one hand, the phrase refers to the serendipity of scientific discovery: the unpredictability of research that generates advancements. Such a justification for continuous, post-war research funding, on the other hand, may minimize accountability of investigators. That is, scientists want money for their work whether or not they make discoveries relevant to national interest (Slaughter & Rhoades, 2004).

[14] Hoch (1988) attributes the formation of post-war research policy and the NSF to the "boundary-elite," a group of academic, military, and industry leaders "who were able to mediate between two or more of the alliance's constituencies" (p. 87). For instance, Vannevar Bush was a vice president at MIT, worked closely with industry partners to fund research and students at MIT, and entered into policy circles at the national level. Elite status in one arena may, according to Hoch, lead to elite status in other sectors and bring together groups whose interests, when they align, shape social institutions. Still, Hoch maintains, those in the boundary-elite did not always work closely together, coalescing only after World War II.

1968), stable, steady funding streams can be difficult to implement due to fluctuations in the economy and tax base. Public interest in science shifts as well, from dominance in space to human health, which also influences funding levels. Agencies such as the NSF, DOD, and NIH do not necessarily tout concentrating funds among elite institutions. And some elite research universities, such as Princeton University, lost shares of national research funding to pursue efforts in undergraduate education (Geiger, 2004).

Disproportionate shares of federal R&D funding to colleges and universities go toward Association of American Universities (AAU) institutions. In 2013, the AAU reports, its 60 U.S. member universities had together received 58%, or $23.4 billion, of total federal R&D funding to colleges and universities for the year (AAU, 2014). These institutions historically and currently capture the largest share of federal and industry funds, resources that buy them prestige (Graham & Diamond, 1997). As discussed in the next part of this section, AAU membership has quantifiable benefits for success in competitive research funding (Ali, Bhattacharyya, & Olejniczak, 2010).

The government and its mission agencies have nonetheless sought to avoid the appearance of selecting “winners and losers” (e.g., institutions and scientists) for funding. Agencies in the post-war era implemented peer-review, deferring to experts to evaluate other experts. But according to one perspective in the literature, science is “peerless” (Chubin & Hackett, 1990). An “old boys’” network of scientists and institutions, some empirical evidence suggests, receive the largest shares of research funding irrespective of merit of ideas. Proposal reviewers do consider the credentials of applicants: where they have received their degrees, with whom they have worked, and in which laboratories they have trained. It stands to reason, then, that elite scientists in the tradition of Vannevar Bush may benefit disproportionately because of their prestige.

As Stephan (2012) notes of peer review at the NIH, overall study impact and significance of proposals have the strongest and second strongest positive correlations with approval for funding respectively. The science itself—the approach, the technology to address the problem, the contribution to knowledge and human health—carries weight. While the NSF employs peer review, its program managers have discretion in funding decisions. Another layer within the national research policy system, peer review presents a decisive development that shapes directions and forms of science and around which universities and scientists must position. It incentivizes the pursuit of scientific opportunities and affiliations to enhance credibility and demonstrate expertise.

The federal research policy system, coinciding with the founding of the NSF, became increasingly institutionalized in the 1950s. Russia's launching of Sputnik into space served to reify, if not also heighten, utilizing research universities and academic science for national purposes. Competition prompted reexamination of national science infrastructure, particularly at universities (Gumport, 1991a, 2011). The National Aeronautics and Space Administration (NASA) and its research funding became increasingly important. In addition, the government heightened funding for students through fellowships and grants, to build a pipeline of future scientists who would contribute to national competitiveness. By the Cold War in the 1960s, defense and national security research maintained prominence. They led in funding and directing resources to academe and scientists—even as faculty and students protested institutional involvement in later-exposed classified projects (Greenberg, 1999, 2001; Leslie, 1993; Slaughter & Rhoades, 1996).

In the 1970s and 1980s, the global economy shifted from industrial to post-industrial and transitioned into knowledge-based competition. The U.S. had lost international standing in manufacturing industries to countries such as Japan. Federal research policy, universities, and science continued to evolve within the context of the surrounding economy and polity.[15]

Republican President Ronald Reagan, who entered the White House in 1981, championed deregulation, privatization, and commercialization. Markets, he advocated, were effective coordinating mechanisms for activities and production to lead toward international competitive advantage. In many respects, AAU university leaders shared Reagan's perspectives (Slaughter, 1993a). They positioned themselves and their institutions' as integral to national competitiveness, evincing commitment not to basic but applied research in the knowledge-based economy.[16]

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[15] Not all science fields co-evolved with federal research policy and changes in the surrounding political economy. Recall that Leslie (1993) found at Stanford resistance among the physics faculty to engage in externally funded defense research. As a result, the applied physics department formed and focused on research using, among other techniques, lasers and plasmas. Discussed in the first section of this chapter, materials science as a field and department also emerged from defense funding opportunities from which the physics department retreated. Such developments, and jurisdictional disputes, suggested to Leslie, "At Stanford, as in other top American university departments of physics, it was all too clear that those small corners [of emerging disciplines and fields] had moved rapidly to the center" (p. 187).

[16] Supply-side economic thought informed many universities' internal allocation of resources as well. Paralleling the federal government's approach, institutional leaders selectively invested in perceived "winners in the marketplace." Justified in economic rhetoric, such allocations in practice did not always follow "mission and market" logic and instead stratified academic departments and faculty by gender (Slaughter, 1998; Volk et al., 2001).

As knowledge-based competition heightened globally in the 1980s, the federal government enacted a series of policies. Together they aimed to harness universities for competitive agendas, codifying perspectives of universities as *economic engines.* Additionally, these policies loosened the legal and regulatory environment to incentivize money-making and market initiatives for innovation (Branscomb, 1997; Dickson, 1984; Eisenberg, 1996; Slaughter & Leslie, 1997; Vonortas, 2000) and catalyze new industries (Bickerstaff, 1999). They also tightened, in other ways, national and international protections for intellectual property (Ganz-Brown, 1999).

To elaborate, the Stevenson-Wydler Act in 1980 established technology transfer operations in federal laboratories to facilitate the flow of knowledge-exchange and profits between government and industry scientists. The Bayh-Dole Act, also passed in 1980, permitted universities to retain patenting rights to discoveries and inventions from federally funded research. It aimed to motivate, with the potential for revenue, technology transfer operations at these institutions, academe-industry links, and academic scientists' research for commercial purposes (Colyvas & Powell, 2006).

Throughout the remainder of the 1980s, several pieces of legislation were intended to heighten knowledge-production and exchange. The Small Business Development Act aimed to support and sustain small business and spin-offs, to build regional capacity for global advantage. To invigorate the medical field, the Orphan Drug Act authorized R&D and sale of specialize drugs and medicines for populations less than 200,000 people, drugs and medicines that can be profitable for universities (see Genetech, an offshoot of the University of California – Los Angeles). NAFTA and GATT provided for international coalitions and networks to advance, exchange, protect, and profit from knowledge and patents. And further legislation loosened antitrust laws, facilitating consortiums in semi-conductors (e.g., SEMATECH) and microelectronics that in prior years was otherwise illegal.

Effects of policy developments of the 1980s, 1990s, and 2000s have garnered much attention from researchers and analysts.[17] These studies consider whether a new policy (e.g., Bayh-Dole) changes the behaviors of universities and faculty members (e.g., an increase in patenting). Mowery and Ziedonis (2001) found minimal effects of Bayh-Dole on patenting activity at elite private institutions, institutions that had patented prior to the policy. Others have observed shifts in "modes" of knowledge production (Etzkowitz & Webster, 1998; Gibbons et al., 1994; Szelényi & Bresonis, 2014) and increased levels, after Bayh-Dole, of basic *and* applied research (Rafferty, 2008; Thursby & Thursby, 2011). Pinpointing behavioral effects of federal research policy on research inputs, outputs, and outcomes may prove difficult. The federal government, Jaffe (2000) suggests, changes a number of aspects of the innovation system at once; we do not know which particular change has prompted which specific outcome, nor do we know the counterfactual of whether such innovation may occur without any given policy.

Still, the history of federal research policy suggests three core insights about universities that persist today and that underpin new, emerging structural forms on these campuses. The federal government has increasingly entwined higher education and economic policy (Berman, 2012; Neave, 1988; Slaughter & Leslie, 1997). Such a move entails efforts to leverage universities for national competitiveness. And institutions position themselves to demonstrate legitimacy for resources.

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[17] See Grimaldi et al. (2011) for a helpful review of literature pertaining to the 30-year anniversary of the Bayh-Dole Act.

Entering the 21st Century, many researchers and analysts have increasingly examined the holistic, structural transformations of research universities in light of federal research policy. Several have observed entrepreneurial institutions that (1) innovate in unproven ways to broaden revenue streams, (2) build administrative capacity to increase external exchanges, (3) stimulate or restructure the academic core in light of market opportunities, (4) evolve a steering core to guide initiatives, and (5) reformulate cultural norms and belief systems to embrace profiting from markets (e.g., Clark, 1998; Slaughter, 2014; Slaughter & Rhoades, 2004; Sporn, 1999). The newly structured universities, collapsing campus boundaries in pursuit of money from government and industry, raise concerns about conflicts of interest for faculty (Campbell, 1997; Yee, 1994, 1997) and institutions (Slaughter, Feldman, & Thomas, 2009; Slaughter et al., 2014). A paradox emerges: universities adapt in structure for relevance but such adaptation may jeopardize some of their integrity.

The incentives for structural change, motivations for emerging SOIs within and across universities, tend to outweigh ethical concerns. In recent years, the federal government has prioritized funding for research in areas such as genomics, cancer, brain mapping, and nanotechnology.[18] Allocation of resources meets the public's "love affair" with the life sciences and policy-makers' strong interest in human health (Stephan, 2012). For instance, as Stephan notes, during his tenure as U.S. senator, two-time cancer

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[18] The federal government can influence academic science based on what it chooses not to fund, as much as it can influence academic science based on what it does fund. During George W. Bush's presidency, the federal government restricted and defunded stem-cell research. A number of states followed the national trend, banning work in this area while others resisted national trends and passed permissive policies (Levine, Lacey, & Hearn, 2013). There has been renewed interest and money for stem-cell research, though the field remains controversial, under President Barack Obama's administration.

survivor Arlen Specter himself nearly boosted the NIH budget from $3.9 billion to $10.4 billion. While the NIH budget doubled between 1998 and 2002, it encountered a bottleneck surrounding the economic recession of 2008 that tightened resources and outlays for research. Universities continue to adapt, and SOIs may prove mechanisms to compete in science and for money.

We may anticipate SOIs positioning and repositioning around the funding priorities of mission agencies. Additionally, we could expect to find SOIs in less prioritized, but funded, areas of research. This chapter has mentioned the primary funders of R&D at universities, the DOD, NASA, NSF, NIH, and DOE, but the Environmental Protection Agency and Department of Transportation also awards money for academic research and sponsors university centers and institutes (Bozeman & Boardman, 2013). Federal money matters. It does not cover the full cost of research, but since the Sputnik era constitutes the largest share of resources for academic science.[19] Institutional prestige depends on federal research funding as well. Many elite universities pursue strategic initiatives for competitive federal funding to increase—or prevent decline—in national visibility and status/standing. The share of funding that universities receive over time effects their positioning in higher education, and fluctuations in federal money can prompt the emergence of SOIs. Increases in money may facilitate innovation from a position of resource advantage, while decreases in money may trigger innovation from being resource threatened. To move toward nuanced understandings of

[19] There are caps on indirect cost recovery at research universities, so that the federal government limits the amount it pays toward the markup that institutions and investigators factor into their funding requests. The markups are not always self-serving or intended to boost research-related revenues. Rather, they aim to (re)cover the cost of actually conducting the research.

environmental influences on SOIs, I address next literature on the AAU to contextualize change and adaptation of elite institutions.

The AAU as Field

The AAU formed in 1900. Since its inception, it has represented—and continues to represent—elite research universities. The organization codified around the interests of early developers of academic research, of institutions that vied for national visibility for their importance to society as producers of knowledge (Geiger 1986, 1988, 1993). Some consider the invite-only AAU a club (Lombardi, 2013; Veysey, 1965), but the AAU also establishes "uniformity of standards" in research for its members (Gumport, 1991a, p. 106). Members meet annually to exchange ideas, develop proposals for federal research funding, and form taskforces to voice opinions on key issues in higher education.

Yet is the AAU a field? Recall that a field can constitute a recognized, agreed-upon area of social life in which organizations homogenize for legitimacy (DiMaggio & Powell, 1983). But a field may destabilize when member organizations contest for scarce resources and jockey for positioning (Fligstein & McAdam, 2012). In this section, I draw on literature to suggest the AAU functions as a field. It forms a social space that influences change and adaptation of universities, for those admitted and those that seek entrance. As a field, the AAU exerts *social control* by way of regulating institutional behaviors based on rewards and sanctions. The rewards and sanctions, membership and dismissal, depend heavily on success in federal R&D funding.

There are 62 members in the AAU, 60 of which are located in the U.S and two in Canada. Of the U.S. institutions 25 are private, 35 are public. AAU's age, small, controlled size, and relative "homophily" of institutions together suggest properties of strong network ties within a field (see Kraatz, 1998). As one field in higher education, AAU reflects not benign categorization of institutions but exertion of influence. It certifies, regulates, and reproduces reputation and prestige, positioning the field and its members for federal R&D funding and national prominence.

Institutions within this distinct field are among the wealthiest in American higher education. They are some of the richest in federal and industry research funding. AAU members constitute a tiny percentage of higher education institutions, yet produce the largest share of doctorates—particularly in STEM (Gumport, 2011). While production of doctoral degrees in STEM marks commitments to research (Gumport, 1991a,b), other metrics also differentiate AAU institutions from peers and are used to determine which institutions in the field are strongest. The AAU determines membership—and which institutions remain members—by federal R&D funding per faculty member, number of post-doctoral researchers in STEM, and, among other criteria, number of awards for faculty members (e.g., number of faculty in the National Academy of Sciences). Of these, federal R&D funding carries the most weight, and AAU institutions must continue to achieve federal funding levels above the field's median. Otherwise they jeopardize membership and the benefits accrued from inclusion.

Institutions outside the AAU have gained shares of national research funding (Geiger, 2004), but universities within the field have long-benefited disproportionately (Graham & Diamond, 1997). AAU membership can increase an institution's likelihood of securing federal R&D funding, though public and private status, among other institutional characteristics, may effect the dollar amount of grants received:

> Although faculty at public institutions that are AAU members are in an advantageous position compared to non-AAU members in terms of securing grants, it is still the faculty at private institutions that gain more grant dollars by being members of the AAU. However, in terms of the number of grants awarded, faculties at AAU private institutions and AAU public institutions are homogeneous in their propensities to secure competitive federally funded grants. Institutional characteristics play a more significant role in effecting the dollar amount of grants than the number of grants. (Ali et al., 2010, p. 175)

As such an observation suggests, public and private AAU members may benefit from being included within an elite field. Analogous to AAU institutions, universities from other tiers and fields may position for external revenues, but endeavors are often less successful than AAU members' initiatives (Turk-Bicakci & Brint, 2005; see also Slaughter et al., 2014).

Pursuit of prestige drives many institutions to seek membership in the AAU or work to retain membership. Success in competition for federal R&D funding can be "cashed in" for status/standing in higher education. Table 1 shows U.S. News & World Report (UNSWR) rankings of the top 25 universities in each of 10 years from 1994 to 2014. UNSWR, though criticized for its methodology, reflects peer ratings of institutions. During a 20-year time period, 86% of the top 25 was in the AAU and either founded or joined the AAU before 1950.

Table 1. U.S. News & World Report top 25 rankings, 1994-2014

1994		2004		2014	
Rank	Institution	Rank	Institution	Rank	Institution
1	*+Harvard University	1	*+Harvard University	1	*+Princeton University
2	*+Princeton University	1	*+Princeton University	2	*+Harvard University
3	*+Yale University	3	*+Yale University	3	*+Yale University
4	*+Massachusetts Institute Of Technology	4	*+Massachusetts Institute of Technology	4	*+Columbia University
5	*+California Institute of Technology	5	*+California Institute of Technology	5	*+Stanford University
6	*+Stanford University	5	*+Duke University	6	*+University of Chicago
7	*+Duke University	5	*+Stanford University	7	*+Duke University
8	Dartmouth College	5	*+University of Pennsylvania	8	*+Massachusetts Institute of Technology
9	*+University of Chicago	9	Dartmouth College	9	*+University of Pennsylvania
10	*+Cornell University	9	*+Washington University	10	*+California Institute of Technology
11	*+Columbia University	11	*+Columbia University	11	Dartmouth College
12	*+Brown University	11	*+Northwestern University	12	*+Johns Hopkins University
13	*+Northwestern University	13	*+University of Chicago	13	*+Northwestern University

14	*Rice University	14	*+Cornell University	14	*+Brown University
15	*+Johns Hopkins University	14	*+Johns Hopkins University	15	*+Washington University
16	*University of Pennsylvania	16	*Rice University	16	*+Cornell University
17	Georgetown University	17	*+Brown University	17	*+Vanderbilt University
18	*+Washington University in St. Louis	18	*Emory University	18	*Rice University
19	*+University of California-Berkeley	19	University of Notre Dame	19	University of Notre Dame
20	*+Vanderbilt University	19	*+Vanderbilt University	20	*Emory University
21	*+University of Virginia	21	*+University of California – Berkeley	21	Georgetown University
22	*University of California-Los Angeles	21	*+University of Virginia	22	*+University of California at Berkeley
23	*+University of Michigan-Ann Arbor	23	*Carnegie Mellon University	23	*Carnegie Mellon University
24	*Carnegie Mellon University	23	Georgetown University	23	*University of California at Los Angeles
25	Emory University	25	*+University of Michigan	23	*University of Southern California
25	University of Notre Dame			23	*+University of Virginia
				23	Wake Forest

University

Source: America's Best Colleges, U.S. News & World Report
Notes: *AAU member. +AAU member inducted prior to 1950. Emory University is noted as AAU member in 2004 and 2014, because it joined the AAU in 1995.

Institutionalization in the AAU does not ensure members' survival in the field. There are sanctions for those that fail to continue to develop federally funded research programs. The Catholic University of America and Clark University were each founding members in 1900 and eventually dropped from the AAU, toward the turn of the century, because they fell into the bottom quartile of AAU universities in federal R&D. After a 102-year membership that began in 1909, the University of Nebraska at Lincoln was removed in 2011 (Selingo & Stripling, 2011). Nebraska was successful in maintaining high levels of funding from the U.S. Department of Agriculture (USDA), but the majority of money from the USDA was non-competitive. Its decline in competitive grants prompted Nebraska's ousting (Carey, 2014). Syracuse University, a member since 1966, resigned from the AAU in 2011 before it was dismissed (Selingo, 2011). A drop in federal R&D funding made Syracuse vulnerable to removal.

The AAU influences institutions on the margins and periphery, prompting wide emulation across higher education of member universities. Because it emphasizes in metrics federal R&D in biomedical research, the AAU has shaped its own institutions' adaptations to form medical schools (e.g., the University of Texas-Austin) and aspiring AAU institutions to form medical partnerships (e.g., the University of Georgia). Part of the field's power comes from its authority to invite, selectively, institutions to join. In 2001, Stony Brook University and Texas A&M University were made members, and in 2010 and 2012 Georgia Institute of Technology and Boston University joined respectively. At their time of entry, these institutions were all above the field median across evaluative criteria. Long-standing members may resist some pressures to change but when they adapt can pursue recourses to remain in the AAU and keep their edge on new arrivals, while young members may enact strategic initiatives to prove themselves worthy.

Within the AAU there are status hierarchies. Johns Hopkins University has the largest share of federal research funding in both raw and scale-adjusted dollars. Harvard University, MIT, Stanford University, and California Institute of Technology (Cal Tech) have institutional wealth that far exceeds other private and public AAUs. As the examples of Catholic, Clark, Nebraska, and Syracuse show, positioning within the field can change based on federal R&D and competitiveness in externally funded science. But change and adaptation of universities may not necessarily be reactive to external funding and AAU pressures but proactive and intended to shape their environments (e.g., Oliver, 1991). In the next section, I discuss the literature on academic strategy, planning, and structure to illuminate campus-level effects on organizational change.

Campus influences on emerging organizational forms

Universities have faced numerous environmental pressures for change and adaptation. Structural shifts in the economy toward knowledge-based competition, technological advancements in society, boosts in student enrollment, decreases in available external funding (e.g., state appropriations), and increases in the number of competing institutions have together transformed higher education (Dill & Sporn, 1995). Not the only impetus behind evolving institutions and structural forms, federal research funding has nonetheless catalyzed a range of responses among universities. Many institutions have employed strategy and planning to negotiate and even anticipate upheaval in their environments—to harness proactive initiatives to shape and fit with external conditions.

At the institutional level, change and adaptation often occurs through strategy, planning, and management. Strategy has a number of definitions, yet generally refers to organizations positioning in relation to external environments. It can be *adaptive* with structural changes and *interpretative* with shifts in culture, meaning, and underlying belief systems of organizational members (Chaffee 1984, 1985). Keller (1983) suggests that strategy refers to deploying resources to defeat one's enemy. It connotes competition, whereby organizations draw on strengths, buffer weaknesses, defend against external threats, and seize opportunities in the environment for advancement.

Planning, in relation to strategy, refers to ways that organizations may work to enact change (Bryson, 1988; Gumport & Pusser, 1997; Rowley, Lujan, & Dolence, 1997). As Peterson (1997, 1998) defines it, planning consists of redefining, redirecting, redesigning, and renewing. Redefining refers to interpreting the environment—and context in which the organization operates. Redirecting entails reformulation of mission: reframing purpose, values, and goals in light of external conditions. Redesigning includes reconfiguring structure and operations as aligned with interpretations of external conditions and organizational mission and (re)purpose. At this stage reshuffling the academic core may very well occur. Finally, renewing is cultural; it entails tapping into and enlivening the campus ethos and members' commitments to change and adaptation.

Management and leadership entails, then, the overseeing of implementation of and accountability for results from tactics.

The literatures on strategy and planning in higher education may overstate the adaptability, the nimbleness, of colleges and universities. Modern-day institutions still reflect in structure, personnel (e.g., faculty), students, and core operations their predecessors of the 18^{h} and 19^{th} Centuries (Clark, 1987). Some organizational structures are highly institutionalized, remaining intact over time because they maintain institutions' perceived, taken-for-granted status and standing as intellectual, moral authorities (Meyer & Rowan, 1977). Once academic departments are created, some suggest, they are difficult to alter or eliminate (Rudolph, 1990; Veysey, 1965). Relative stability may underscore influences from institutional fields, normative expectations for upholding "charters" with society (Kamens, 1971, 1977). Anticipated or felt shifts in resources, especially financial, can motivate strategic change.

Conditions of decline—dwindling demand and resources needed for producing services—may lead to adaptation. As Cameron (1983, 1984) suggests, institutions may employ domain defense, offense, and creation to reestablish equilibrium with external environments. Domain defense entails protecting the legitimacy of the institution's chief activities (e.g., the products and services offered). Domain offense entails continuing to do the "right things," pursuing the exact set of activities that maintains and enhances the institution's viability. Domain creation entails entering into and pursuing new and different activities that enhance the institution's portfolio and survival. Institutions may also employ domain substitution, to switch one set of activities for another, and domain deletion—eliminating activities to pursue those best aligned with counteracting conditions of decline (Cameron & Zammuto, 1988). In higher education, we may see colleges and universities utilize domain strategies when they reengineer administratively (Balderston, 1995) and restructure the academic core (Gumport & Pusser, 1999).

Many researchers and analysts have focused on ways in which entire universities adapt (e.g., Clark, 1998, 2004; Gumport & Sporn, 1999; Slaughter & Rhoades, 2004; Sporn, 1999). A common impetus for many of these institutions has been deepening engagement with markets to diversify and strengthen revenue streams. These pursuits could lead to prestige in higher education (Geiger, 2004), while providing economic resources necessary to finance competitive strategies (Hearn, 1988).

Focusing on institutions holistically has been helpful, but knowledge gaps remain. We gain broad insights into how institutions position themselves, yet missing are fine-grained understandings of *how* change and adaptation occurs (Hardy, 1990) and by *whom* (Gumport & Pusser, 1997). What is more, we continue to lack understandings of why organizational units emerge, decline, die, merge, split, are promoted or demoted (Hearn, 2007)—and why these adaptations occur and vary as they do.

Research on organizational change and adaptation in higher education has developed somewhat slowly. Literature in this arena often comes from the organizational sciences, with higher education organizational literature, observers note (Hearn, 2007; Peterson, 1985), incrementally transitioning from infancy toward adolescence. Insights from the organizational sciences have nonetheless offered initial understandings of what happens within institutions, shedding some light on how and why such adaptations may manifest themselves.

Keller (1983) provides an oft-cited example of one perspective from business that can be used to inform strategy, planning, and management in higher education. Reporting a concept from the Boston Consulting Group, he suggests that academic departments are profit centers that institutions should manage as part of their investment portfolios. Academic departments, when situated within the Boston Consulting Group's approach, can thus fall each into one of four portfolio categories: "stars," "cows," "question marks," or "dogs." Stars are high in quality and student demand. Cows are high in quality but low in student demand. Question marks are high in student demand but low in quality. Dogs are low in quality and student demand. According to the grouping scheme, institutions' assessments are intended to result in investments in stars and cows, some investments in questions marks (to turn them into stars), and disinvestment from dogs.[20]

Institutional leaders and managers have leeway in determining which departments belong to which categories. The field in which a department is situated may not necessarily indicate the unit's status on campus. We may anticipate finding variation across institutions in departments designated stars, cows, question marks, or dogs. For instance, Pennsylvania State University's nanotechnology unit may be considered a star, but at Princeton University a question mark or dog. Specialized niches in which institutions operate may thus factor into groupings and categorizations of departments.

[20] Rowley and Sherman (2004) propose an academic program mix that campus leaders and managers can oversee as part of strategic planning (see also Shirley, 1988). The academic program mix is "a portfolio of courses and program offerings available from the institution including the prioritization of those programs and the relative expectation of new program development over time" (p. 92). The emphasis on educational offerings differentiates the Rowley and Sherman model from the Boston Consulting Group's, with the latter's suggesting changes not just to programs but also organizational structure.

"Quality" of academic departments may be assessed through productivity, effectiveness, and mission centrality and inter-unit connectedness. As Middaugh (2001) suggests of productivity, we may evaluate departments (and faculty) based on, among other indicators, credit-hour production and research outputs, but such quantitative data limit understandings of department quality (Hearn & Gorbunov, 2005). Effectiveness can be measured by way of student academic outcomes, faculty productivity, caliber/prestige of faculty, graduates' placement in jobs, and morale of clients (students) and producers/service providers (e.g., faculty) (Cameron & Tschirhart, 1992). But evaluation of departments may also include the degree of overlap between unit and institutional missions and the extent to which units are entwined with each other.

Hackman (1985) suggests that departments demonstrating centrality and connectedness are more likely than other departments to secure internal resource allocations. *Centrality* means that departments' missions closely match and serve the missions of their home institutions. *Connectedness* indicates the extent to which one department relies on another (e.g., whether students from one department are required to take courses in another department). Such an observation suggests the politics of institutions and departments.

As Gumport (1991b) suggests, quality can be subject to political spin. Departments may tout quality, or provide information to central administration that facilitates the perception of their units as mission-relevant stars. Perceptions among administrators of centrality in particular can be influenced politically: some departments may have faculty who become administrators, administrators who may genuinely see their departments as central to their institutions missions, purpose, and goals.

Connectedness may seem "collegial" but also carry competitive undertones, as some departments seek to gain leverage in relation to others by way of course duplications that take peers' market share of students.

College and university campuses may reflect loosely coupled systems and, in light of political dimensions, organized anarchies (Birnbaum, 1988; Cohen & March, 1986; Weick, 1976). Particularly at large research institutions, loose coupling may occur between departments (and people) that have infrequent time and place interactions. A system can become loosely coupled when units and subunits interact infrequently over time—and units and subunits are loosely coupled to central administrative structures. Localized adaptations may occur in which departments respond quickly to their immediate disciplinary environments, but these adaptations do not necessarily spread across entire institutions. On the other hand, institutions that seek to implement wide-spread change across campuses may have difficulty.

Within a loosely coupled system, units and subunits may cooperate and compete for scarce resources. When departments interact, it could come through periodic coalitions formed around particular organizational issues. Alignments may shift—or drop—depending on specific matters at hand (e.g., budgeting, faculty hiring/tenure lines, parking systems, library resources, building/maintenance requests, etc.).

Political aspects of institutions, and which departments prosper over others, have long held attention of researchers and analysts. Salancik and Pfeffer (1974) and Pfeffer and Moore (1980) each suggest that departments receiving external resources (e.g., grants and contracts) are more likely to win internal, institutional resources. In particular, Pfeffer and Moore find that the "paradigm" of the department matters: units high in consensus about methods, tools, techniques, problems to address, and theories (e.g., physics, chemistry, and biology) may have a more focused, precise way of communicating about its needs to external funders. They may be more likely than low-consensus units (e.g., English, history, and philosophy) to secure external and internal funding. Contesting for scarce resources may thus heighten the micropolitics of campuses (Pfeffer, 1978).

Organizational structure can emerge and codify around negotiations of power. According to Perrow (1986), power is "the ability of persons or groups to extract for themselves valued outputs from a system in which other persons or groups either seek the same outputs for themselves or would prefer to expend their effort toward other outputs. Power is exercised to alter the initial distribution of outputs, to establish an unequal distribution, or to change the outputs." (p. 259). According to such a definition, power is not necessarily about increasing the size of the pie, but rather about allocating the various pieces of the pie.

In higher education, many institutions engage "in a constant struggle for autonomy and discretion [and are] confronted with constraint and external control" (Pfeffer, 1981, p. 257). From a resource dependence perspective, colleges and universities may change and adapt to exert leverage over environments and reward those units that help them achieve power (Salancik & Pfeffer, 1978; Tolbert, 1985). Over time, once newly formed resource-exchanges may become long-standing commitments, routinized and predictable between organizations and external stakeholders (Kraatz & Block, 2008; Kraatz & Sajac, 2001; Selznick, 1992).

Such a perspective may underscore the emergence of new organizational units, such as research centers and institutes (Geiger & Sá, 2008). These organized research units (ORUs) have "allowed American universities to expand selected parts of their research commitments in response to social demands as manifested in the availability of research funds" (Geiger, 1990, p. 16). Academic departments that receive external resources, which institutions may harness to diversify revenue streams and increase financial autonomy, may also be championed and rewarded internally. In this way, institutions and organizational units have interdependent relations with each other and external political and economic actors and organizations.

In her study of the emergence of women's studies programs, Gumport (1988) found that feminist professors drew on connections and interests outside of academe in order to influence and implement change within institutions. That is, the political and social movement of feminism in society presented one way for professors to organize and gain legitimacy for women's studies in the academy—scholarship once considered "too radical" for the academic core. As Slaughter and Silva (1983) note, the professionalization of social scientists and the legitimacy of social science departments occurred because of social scientists' connections and perceived utility to industry and business professionals. Recall that academic scientists too have positioned themselves and their fields as central to national security and economic competitiveness (Slaughter & Rhoades, 1996; Wolfle, 1972). Power, resources, and governmental policy can prompt substantive shifts within institutions and organizational units.

Academic program restructuring and retrenchment illuminate interactions of institutions and departments with broad political, economic influences. Leaders and managers often develop specific decision rules to guide retrenchment, but tend to diverge from their own "rational-choice" intentions (Eckel, 2002). Program closures may have little to do with actual subject matter and knowledge-bases and more to do with the way in which departments (and faculty) and institutions are situated within the political economy (Gumport, 1993; Slaughter, 1993b). Clearly, there are some connections between department and subject matter and political economy: departments with clear market-ties, such as STEM disciplines, may continue to vie for and receive external funding, positioning them competitively among institutional leaders and managers and also state and federal policy-makers. But departments distant from markets, such as the arts, humanities, and social sciences, can and often do find themselves vulnerable to closures in times of resource constraints (Gumport, 2000; Gumport & Pusser, 1999; Manns & March, 1978; Slaughter, 1993b).[21]

Studies of resource allocation models indicate, in part, institutional preferences for STEM fields, units, and professors. As Volk, Slaughter, and Thomas (2001) found at one institution, departments perceived close to research and labor markets, and that graduated a high proportion of graduate students, received higher levels of institutional funding than others. Additionally, departments that framed their missions as connected to the institution's received a higher proportion of internal allocations than other departments. But departments with higher proportions of women than men (such as in the

[21] Washington University in St. Louis closed its sociology department in the late 1980s to repurpose funding for other programs. In 2014, amid mass protests in Missouri over racial inequality and stratification, the university re-founded the department (Monaghan, 2014). As the re-birth of the sociology department suggests: the social sciences may receive about 2% of all federal R&D funding, but can carry societal importance and help institutions position themselves as relevant and responsive to external communities and stakeholders.

arts and humanities) often received lower institutional funds than departments with higher proportions of men to women. Slaughter (1998) suggests that feminist theories must be considered in interpreting and evaluating resource allocation models. Thus what permits a department to flourish and ultimately splinter into further specialized fields may be a function of mission and markets and also gender composition.

There are countertrends, however, in where and to whom institutional leaders allocate resources. In their study of academic units at San Jose State University (SJSU), Gumport and Snydman (2002) found that over a 45-year period, the institution accreted departments and academic programs on campus. Many colleges and universities have bolstered STEM programs to compete for prestige and resources. At SJSU, structural growth occurred mostly in the arts and humanities and programmatically at the master's level. While the number of departments increased over time, programmatic growth exceeded the count of units. New programmatic areas do not necessarily require additional personnel, making them more cost-effective than new human resource-intensive departments. Overall, these patterns at SJSU could reflect resource-sensitive strategies to pursue niche markets. They may further indicate institutional strategy to strengthen liberal arts programs to demonstrate prestige in higher education (Abbott, 2002) and shift some programs toward new arenas of student demand (Manns & March, 1978; Jaquette, 2013) and professional preparation (Brint et al., 2005; Slaughter, 2002).

Institutional budgeting and resourcing systems can be powerful in incentivizing change and adaptation in the academic core (Balderston, 1990; Powers, 2000). To temper costs and boost revenues, some universities have pursued Responsibility Center Budgeting (also known as Revenue Center Budgeting) (Strauss, Curry, & Whalen, 1996;

Whalen, 1991). Departments become responsible for generating revenues to cover their costs. RCB has merits. It accommodates the professional bureaucracy of many institutions, in which professionalized faculty draw on autonomy and perform main organizational tasks of teaching, research, and service. The budgeting system could empower those who produce revenues to become mindful of and work to balance costs.

Yet RCB could enhance politics and competition across departments. Some units may duplicate classes offered in other disciplines to expand programs and credit-hour production and revenue, but to the detriment of other units. Some departments may increasingly pursue external revenues and federal research funding, which could come at the cost of teaching and instructional quality (Massy & Zemsky, 1994). Undergraduate students could increasingly absorb the costs of research, as they subsidize through tuition and fees the pursuits of faculty in commercial and market endeavors (Ehrenberg, Jakubson, & Rizzo, 2003). And it remains difficult to assess whether departmental outcomes are tied to the implementation of the budgeting system (Hearn et al., 2006).

For institutions and departments that move closer to markets, there can nonetheless be powerful results. The emergence of the biotechnology industry has been attributed to interactions of universities, departments, professors, industry partners and labs, and government funding and policy (Kenney, 1986). Pharmaceuticals have flourished in the U.S., attributed to contributions from chemists and chemistry departments (Swann, 1988). As Geiger and Sá (2008) note, “tapping the riches of science” may, albeit not always, prompt lucrative outcomes. Developments in nanotechnology, computers, semiconductors, and broadband and Internet may benefit economic-development collaborators, regions, and the nation. Organizational adaptations within and surrounding the academic core of colleges and universities may reify these nascent industries and clusters. Institutes and centers may bring together researchers from multiple disciplines to work on specific technological problems. Academic departments may adapt as well, though by varying degrees (Mendoza, 2012), to position their fields and disciplines for resources and political, economic interests that lead to further specialized areas of study; other fields and disciplines may decline, if not die (Slaughter & Rhoades, 2004; Slaughter, 2014).

Many researchers and analysts have suggested concepts to account for organizational change and adaptation in higher education. Simsek and Louis (1994) found that institutional paradigms are central in driving change; shifting incrementally how organizational members understand and make meaning in their environments may ultimately inform revolutionary shifts in outlooks and underlying belief structures. Chaffee (1985) suggests the importance of structural and interpretive/symbolic strategies. Structures themselves have been deemed important, for they are the vehicles that may carry forward and sustain change (Clark, 1998). Cultural underpinnings and organizational sagas can be utilized to harness collective commitments to ongoing change and adaptability (Clark, 1972; Peterson & Spencer, 1990).

Mintzberg and Westley (1992) advance an intriguing conceptualization of organizational change and adaptation. They note how change can occur through, among other mechanisms, enclaving, cloning, and uprooting. Institutions may seek to delimit change only to one aspect of the organization, controlling its flow and spread (e.g., enclaving). Some organizations may create spin-off entities that carry forward change, without affecting the main organization itself (e.g., cloning). Finally, uprooting entails the physical movement of organizations from one location to another, demanding steadfast devotion and commitment to core, fundamental beliefs (e.g., uprooting).

In the origins and nature of SOIs, we could expect to see enclaving and cloning.[22] The loose coupling of institutions may prompt enclaving: adaptation of centers and institutes on the periphery and distanced from the core of institutions. But enclaving can also explain school- and department-level innovation. A School of Engineering may add a unit for computer-engineering in light of external stimuli (opportunities for industry partnerships, calls for participation in economic clusters, pursuits of federal and state research funding, etc.), while a School of Arts and Sciences remains relatively stable in curricula, units, and research programs. Cloning could perhaps best explain the emergence of SOIs. The Department of Biology may "replicate" itself structurally but as a center or institute in genomics. Such a move can accommodate (and contribute to) advancements in the life sciences and position the new entity, and its campus-level funders, for external resources.

Analogous to the strategy literature in higher education, the Mintzberg and Westley (1992) conceptualization does not indicate the role of resources in strategy (Hearn, 1988). We could anticipate institutional pursuits in structural innovation to differ by available funds. Institutions that are resource-threatened could opt for enclaving, experimenting in organizational form but in a way that does not compromise long-standing commitments with its relatively small but crucial contingent of resource

[22] An example of uprooting may be affiliated non-profit organizations (ANPOs). To compete for resources, public and private universities amass assets in ANPOs, which are tax-exempt and buffered, legally, from state-level scrutiny (Taylor, Barringer, & Warshaw, 2014). ANPOs are spin-off entities but with direct ties (e.g., allegiances) to their home institutions.

providers (Sherman & Rowley, 2004). In contrast, institutions that are resource-strong could pursue somewhat risky endeavors of cloning, which require high front-end investments without proven track records of success and possible displacement of core structures and operations around which they have formed their commitments with external resource providers.

The literatures on strategy, planning, and academic structure suggest the *campus-level* politics and resources that undergird organizational change and adaptation. There has been a strong focus on program closures and restructuring—and for good reason. Decisions to eliminate units and faculty positions send visible, resonant messages about which disciplines and fields are most important to institutions and society. But such emphases preclude consideration of innovations and the processes that drive new, emerging forms. They depict as well divergence between administration and faculty, whereby administrators leverage budgets and institutional policy to exert influence over faculty members and academic structure. This is problematic because faculty and administrators could very well work together to form new, spin-off entities to capture resources and attain the cutting-edge in science.

We need a conceptual model that explains SOIs and that balances the market, academic capitalism perspective (e.g., Mendoza, 2012) with other ways of interpreting structural change in elite research universities. What is more, we need a conceptual model to account for examples of resistance (Slaughter, 2014). Such a theoretical perspective could explain why SOIs vary from institution to institution and how that variation relates to strategic response (e.g., Oliver, 1991). In the next chapter, I draw on institutional theory, resource dependence theory, and academic capitalism to conceptualize the nature and emergence of SOIs.

Summary

SOIs suggest great variation in form, origins, and operations. Their variety, positioning them around any number of scientific niches, funding sponsors, faculty initiatives, and institutional goals, suggests strategic advantages for universities that adopt them. Within the context of formal organizational hierarchy, SOIs can be situated in matrices. They can have vertical, horizontal, and orthogonal links, as well as informal network affiliations, which facilitate *fluidity* and *continuity* of money, research, and faculty members across the research core. Federal research policy and funding incentivizes structural adaptations of universities, and the AAU confers and reproduces prestige based on member success in federally funded science. But universities can enact strategy and planning to shape or deflect rather than outright react to their environments. Knowledge gaps remain, however, suggesting needs for a theoretical framework to conceptualize the nature and emergence of SOIs. Such a framework could explain why institutions develop their particular continua of SOIs and the roles of resource and field positioning in prompting alacrity, inertia, or resistance. Furthermore, a conceptualization is needed that accounts for strategy from the "ground up," accounting for the locus of action—entwinement of faculty and administrators—that incites and institutionalizes change.

CHAPTER 3

THEORETICAL FRAMEWORK

This chapter presents a theoretical framework to account for the nature of variation and emergence of SOIs. To this end I draw on institutional theory, resource dependence theory, and academic capitalism. Institutional theory suggests that organizations become institutions when they are imbued with value and meaning beyond technical efficiency, drifting then stabilizing structurally toward normative expectations and resources of stakeholders. Resource dependence theory explains the differentiation of organizational structure to help institutions increase autonomy and managerial discretion by way of spreading reliance on funding across numerous sponsors. Academic capitalism suggests the money-making motives of universities that prompt structural and behavioral recourse to markets and erode service to the public good. While the theories differ in their explanations of structural adaptation in the research core, they share three main assumptions. They assume an open systems perspective in which institutions have permeable boundaries; organizational structure mediates institutions' relationships with external environments; and resources—how they are allocated, committed, and shifted—indicate priorities, values, and goals.

The three theories differ in important ways. In contrast to institutional theory and resource dependence theory, academic capitalism problematizes delineations of where institutions and environments begin and end. It conceptualizes networks among constellations of actors and organizations to compete in and profit from market activities.

Academic capitalism has become so germane as a theory, so central in explaining entwinements of economic policy and universities, that its two primary books by Slaughter and Leslie (1997) and Slaughter and Rhoades (2004) have together generated by 2015 over 6,000 citations. What is more, the theory of academic capitalism has informed the conceptual basis for 987 doctoral dissertations. Yet academic capitalism may make some claims about institutions that are stronger than available empirical evidence. Context matters (Bozeman & Boardman, 2013; Mendoza, 2012), and longstanding histories and resource dependencies of institutions can shape strategic change (Kraatz & Block, 2008; Oliver, 1991).

The differences among the three theories give them, when brought together into a conceptual framework, explanatory power. They fill in gaps of each other. This chapter is thus organized into five sections. First, I address institutional theory. Second, I discuss resource dependence theory. Third, I present academic capitalism. Fourth, I draw on the three theories to explain the various aspects—dimensions—of the organizational matrix in which SOIs are often situated and conceptualize a quadrants of innovation model. Finally, I summarize the preceding sections and build toward the research questions of this thesis.

Institutional theory

Institutional theory explains how organizations become institutions when they are infused with meaning and value beyond their technical efficiency. Institutions have "charters" with society (Kamens, 1971, 1977) by which they aim to uphold legitimacy for resources and stakeholder support to sustain them. Organizational structure can maintain the ceremony and myth—the appearance—of effectiveness, affirming organizations' importance to both internal and external constituents (Meyer & Rowan, 1977; Meyer & Scott, 1992). It may symbolize long-standing commitments that institutions intend to keep, commitments to goals and values and resources-exchanges in which they participate (Kraatz & Block, 2008; Kraatz & Sajac, 2001; Selznick, 1957, 1992, 1996).

In higher education, institutions tend to buffer operational cores from external scrutiny to increase autonomy and extend taken-for-granted beliefs in their intellectual, moral authority. As institutional theory suggests, social distance may characterize organizations' relations with environments. They can withdraw some in shrouding technology, while deepening entwinements externally by leveraging structure for legitimacy and resources (e.g., students, faculty, funding, etc.). Histories and cultural traditions of organizations can become embedded, that is, "institutionalized," in organizational structures and present "a formidable collection action problem" (Jepperson, 1991, p. 151). Engrained ways of structuring and operating prevent easy dislocation or goal displacement. They may fortify barriers to change and adaptation. The economic and social costs of innovation may prove too high, too risky, to undertake, for they may compromise "charters" and commitments. They may erode values and taken-for-granted status and standing as institutions.

A number of critics highlight the limitations of institutional theory to explain organizational change and adaptation (e.g., DiMaggio, 1988; DiMaggio & Powell, 1983; Fligstein & McAdam, 2012; Slaughter & Rhoades, 2004). They rightfully note that institutional theory suggests stability to minimize uncertainty. History, Selznick (1957, 1992, 1996) suggests, may hold institutions hostage because it maintains continuity and thus predictability in what they do and for whom and in who they are in their core identity. Change threatens the status quo—and values. But institutional theory does account for the sway, the drift, of institutions over time and in some unanticipated ways.

Institutions are, by their nature, institutionalized in their own rights but situated in complex, overlapping environments. As Kraatz and Block (2008) suggest, institutional pluralism can explain the ways in which public research universities "play" in many games at once and are subject to multiple (and at times conflicting) sets of rules and constituents. For instance, these institutions compete for federal research funding, position in relation to peer and aspirant institutions, navigate state contexts of finance and governance, engage the various academic fields and disciplines, rely on and aim to recruit professionalized faculty, and have commitments to undergraduate and graduate students and compete in these markets as well (see also Geiger, 2004). In the words of Clark Kerr (1994), "The university is so many things to so many different people that it must, of necessity, be partially at war with itself" (p. 7). The various units and subunits, goals, and activities within universities may reflect constant strain and tension, and the increasing demands and people surrounding universities opens these institutions to continuous opportunities for change and adaptation. As has been the case in other organizational sectors, some institutions could, in such dynamic environments, displace their goals to adapt to survive (Selznick, 1949, 1960). Discretion over planning functions could lead these institutions to take on lives of their own, integrating various internal and external demands with a distinct identity.

Institutions, as organic entities, can drift toward external stakeholders. Colyvas and Powell (2006) found that opportunities in Stanford University's external environment to make money from intellectual property coincided with shifts in faculty and administrator attitudes toward and rewards for patenting. In turn the pursuit of research for money at Stanford became legitimized and, because of the institution's visibility, status, and stature in higher education, widely emulated. For SOIs on campuses we may anticipate finding centers and institutes, for instance, which reflect in their type, scientific niche, and sponsorship direct positioning around distinct sets of constituents. Some may hold direct links to federal mission agencies, others to private donors and philanthropists. From the perspective of institutional theory, institutions may not have intended to move in these directions but have done so because of external resources, and, over time, such changes and adaptations become expected structural forms and operational commitments.

But institutional theory does not address well issues of power. Recall from Chapter 2 that Perrow (1986, p. 259) defines power as

> the ability of persons or groups to extract for themselves valued outputs from a system in which other persons or groups either seek the same outputs for themselves or would prefer to expend their effort toward other outputs. Power is exercised to alter the initial distribution of outputs, to establish an unequal distribution, or to change the outputs.

As such a perspective suggests, external stakeholders may exercise power when they influence structural adaptations of universities to position them for their own advantage. Federal missions agencies do not tell institutions how to structure to advance science and compete for money, but allocate funding in such a way as to incentivize universities to change to serve national interests. Power, of course, can emanate within universities among faculty and administrators who create organizational forms to position for their goals of research, visibility, prestige, and money.

Closely related to power, politics receives scant consideration in institutional theory. Because institutional theory explains stabilization of organizational structures, it tends to miss micropolitics and power dynamics that become infused within institutions. Times of resource fluctuation—particularly resource scarcity—can prompt de-institutionalization (Covaleski & Dirsmith, 1988) whereby existing, embedded structural and budgetary aspects of institutions break down and re-emerge anew to align with presiding interests (DiMaggio, 1988). While institutional theory suggests the importance of leadership to use "guiding hands" to steer institutions to maintain integrity and viability (Selznick, 1957), such portrayals of leaders overlook self-interests of those who leverage institutions to meet their own goals.

What is more, the Selznickian "old" institutional theory does not address field-level dynamics that move institutions toward homogeneity. A field may have relative cohesion and durability (Giddens, 1979), though it can destabilize amid scarce and contested resources (Fligstein & McAdam, 2012). In times of uncertainty, when organizations do not know probabilities of outcomes relative to costs, its field of competitors tends to offer cues about how to proceed (DiMaggio & Powell, 1983; Kraatz, 1998).

Mimetic influences may emerge, in which organizations copy those whose solutions have appeared successful. *Coercive pressures* can manifest themselves through legal or regulatory changes, which could empower or restrict organizations. *Normative expectations* may be especially strong, with professional field and networks suggesting how organizations ought to change and adapt. *Isomorphism* tends to ensue, for organizations within a field often innovate in strikingly similar ways. Adopting comparable innovations may restore balance externally, as such moves may reaffirm not operational efficiencies and technical precision but legitimacy.

As administrators and faculty each and together form SOIs, they may shift organizational structure to meet changing national expectations. In the knowledge-based economy, having units dedicated to nanotechnology, optics, microelectronics, and computer engineering, among other disciplines, may signal institutions' importance. It can communicate relevance to justify continued federal R&D funding. Universities may adopt comparable innovations to uphold their institutions'—and field's—status/standing. Institutional theory suggests possibilities of homogeneity in innovations across universities. But institutional theory does not address power of the environment or institutions negotiating resource dependencies to pursue autonomy.

Resource dependence theory

Resource dependence theory explains how organizations may influence their external relations to increase managerial discretion. It positions the environment—particularly resource providers—as exerting degrees of control over organizations (Pfeffer, 1981; Salancik & Pfeffer, 1974). Pfeffer and Salancik (2003) define control as "the ability to initiate or terminate actions at one's discretion" (p. 259). They further identify conditions that influence the degree of external control of organizations (p. 260):

- Possession of resources by social actors
- Criticality of resources for organizations' core activities and survival
- Limited opportunity to obtain the needed resources elsewhere
- Visibility of behavior or activity being controlled

- Social actors' leverage to take the desired actions
- Organizations' leverage to take the desired actions
- Organizations' lack of control over resources critical to social actors
- Ability of social actors to make preferences known to organizations

SOIs, within and across universities, seem to fit these points well. Federal mission agencies have the money to fund scientific research, the most crucial and largest share of resources for such activities. Positioning for federal research funding is highly visible and national, with status/standing as elites contingent upon success. Yet universities, by way of SOIs, influence the research itself, which carries implications for national economic competitiveness. And funders and institutions manifest their goals that can diverge around issues of dependence and autonomy.

Universities, from the perspective of resource dependence theory, may change and adapt to maximize resource flows, minimize uncertainty, and mediate influences from stakeholders. In contrast to institutional theory, resource dependence suggests that structural innovations are about power: the ability to shape relations to prompt outcomes that meet particular but not necessarily collective goals (Perrow, 1986). As Scott and Davis (2006) observe, "The emphasis on power, and the careful analysis of the repertoires available to firms to pursue it, is the distinctive hallmark of resource dependence theory" (p. 233).

Universities may adopt administrative structures to diversify and optimize revenues (Kraatz et al., 2010; Tolbert, 1985). Edelman (1992) suggests structural innovations can be symbolic, intended to demonstrate the appearance of new commitments and compliance to regulatory environments but decoupled from pursuits that favor managerial discretion. According to such a perspective, resource dependence theory suggests an underlying motive for change and adaptation, while institutional theory accounts for ways in which once-perceived innovations, and their new values, may become taken-for-granted among stakeholders (e.g., Covaleski & Dirsmith, 1988).

SOIs, analogous to administrative accretion, may not enhance operational efficiency, but can help institutions balance reliance on and secure external funders. Universities may invest in emerging STEM disciplines because these fields can attract federal R&D funding (see Pfeffer & Salancik, 2003). Grants may decrease overreliance on dwindling state appropriations or endowments, aiming to broaden sources of funding for some institutions. Moreover, grants often provide some discretionary money (e.g., slack resources) over which institutions control. Structure, then, could have antecedents in campus micropolitics (Pfeffer, 1978) and interdependencies with and commitments to external actors and stakeholders.

Resource dependence and institutional theories may complement one another, addressing variation in organizations' adoptions of innovations. Within a field, institutions may differ in resources and leverage over resource-providers. Let us consider an example. The University of North Carolina at Chapel Hill (UNC) has broad, robust portfolios of investments and revenues. University of Arizona may capture federal R&D funding, yet has comparatively limited state funding from which to draw. Both institutions have medical schools and are Association of American Universities (AAU) members, but could innovate in STEM units for divergent reasons; the substantive nature and form of their respective innovations may differ.

UNC could create a nanotechnology department and cover start-up costs, while Arizona meets financial barriers to codify a new discipline as department. Because of deep and diverse resource pools, UNC may resist developing a nanotechnology department even as other AAU members pursue it. Arizona may be susceptible and increasingly sensitive to field cues and opportunities to diversify revenues, thereby seeking to innovate in nanotechnology. As Kraatz and Sajac (2001, p. 634) note:

> Because the returns from exploiting existing resources are generally more certain than those from exploration, the former often drives out the latter. Thus, the very possession of valuable resources paradoxically leads resource-rich organizations to focus an increasing amount of attention upon applying and improving them, at the expense of exploring and developing the new resources which are often required for strategic change.

In this hypothetical case, UNC could choose not to develop nanotechnology in order to heighten revenues through already-established, "institutionalized" channels. But Arizona may demonstrate increasing alacrity in pursuit of resources, moving to open then codify external funding streams. Both institutions can be said to deploy their resource-bases but toward differing ends, to uphold and strengthen existing relations or create and affirm new ones (Kraatz & Block, 2008).

Resource dependence, and the nature and stridency of shifts within an institutional field, may account for a range of strategic responses. Organizations may acquiesce, compromise, avoid, defy, or manipulate the field to balance external control and autonomy (Oliver, 1991). Power may inform institutions' directions, as well as how deeply they integrate field-driven changes. Yet newer members of fields, those less institutionalized and engrained normatively, could differ in their sensitivities to change and adaptation as compared to founding and/or long-standing members.

An AAU member since the field's founding in 1900, Princeton University may catalyze trends that others, such as Boston University (joining the AAU in 2012), could move to adopt. In fact, Princeton's "age" and resource-embedding may suggest its cumulative history of experiences and funding position, its continued fine-tuning of structures and activities that have sustained and financed the organization over time (Hannan & Freeman, 1977, 1984; Kraatz et al., 2010; Levinthal, 1991). Or institutions such as Georgia Institute of Technology, an AAU member since 2010, may innovate structurally to gain entry to the field, while Princeton may remain relatively stable amid its long-enduring prominence. Combinations of resource interdependencies and field status/standing may together mediate the emergence of SOIs.

Resource dependence theory assumes inter-penetration of organizations and environments, prompting questions of boundaries. As Pfeffer and Salancik (2003) suggest, environments are not necessarily objective realities but "become known through a process of enactment in which perceptions, attention, and interpretation come to define the context for the organization" (p. 260). Such a perspective suggests a process of *social construction* through which organizations define—and come to know—their external environments. But in the age of academic capitalism, the organizational and the external can become difficult to delineate. *Fluidity* can characterize these dynamics, in which networks open and coordinate exchanges between organizations—their structures, operations, and people—and stakeholders. The theory of academic capitalism can help us move beyond resource dependence to contemporize change and adaptation in higher education.

Academic capitalism

Academic capitalism offers some gains in analytical purchase as compared to institutional theory and resource dependence theory. It problematizes delineations between fields and environments, as well as institutions and external stakeholders. The theory suggests structural shifts in the policy environment within which universities change and adapt in organizational form and behavior (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004; Slaughter, 2014). In this way, academic capitalism covers multiple units of analysis to explain overlapping changes in policy, fields, institutions, units and subunits on campuses, and social relations among people.

A prevailing market ethos, academic capitalism suggests, can collapse university-environment boundaries. Pursuits of revenues from high-technology arenas may entwine and reify a network of government, industry, and university actors. Collaboration may prompt new campus administrative structures to facilitate external partnerships (e.g., in licensing, patenting, technology transfers, etc.) for competition in and profits from markets. Targeted allocations to institutions from federal and state sponsors, investments in science and technology research and infrastructure, can overlay universities' own selective resource decisions.[23] But "supply-side" economic practices may deepen stratification of academic departments and professors. Perceived producers in the marketplace may gain disproportionate shares of funding that incentive and finance further innovations in knowledge-production and –exchange (e.g., new disciplines and

[23] Government allocations for strategic research initiatives on campuses often serve dual purposes (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004). They support R&D in science and technology, but also encourage additional risk-taking for universities. In this way, universities may become increasingly entrepreneurial and *market-like*: they do not necessarily "lose" in the marketplace because their efforts are publicly subsidized.

"circuits of knowledge") and organizational structure. Together, tenets of academic capitalism suggest that structural innovations may help adaptive universities affirm political, economic roles in society (see also Gumport & Pusser, 1999).

Academic capitalism encourages our questioning of which actors and organizations are situated within and external to a field. The field environment can include a group of universities, such as AAU institutions, but also government and industry partners (Berman, 2008; Campbell, 1997). Federal research policy may be somewhat endogenous to the field, a once "external" catalyst of change and adaptation increasingly embedded within a delimited network. Within this social space universities may become active agents in seeking to shape policies and funding streams that subsidize competition and pursuit of profits from markets. Yet some claims of academic capitalism could be stronger than available empirical evidence suggests. That is, academic capitalism may in some cases be *ascendant* though not necessarily dominant or fully integrated (Slaughter & Rhoades, 2004).

Not all institutions or academic departments may transition into academic capitalist regimes. Despite fears that centers and institutes substitute education for "a kind of academic capitalism, an orientation toward profit rather than education" (Ikenberry & Friedman, 1972, p. 97), emerging organizational forms do contribute to teaching missions of their home institutions (Bozeman & Boardman, 2013). Some academic departments embrace industry partnerships, but others seek unrestricted grants to support research rather than to generate discoveries for profits (Mendoza, 2012). Academic capitalism as a theory may underscore market aspirations not quite realized and could thus benefit, as Slaughter (2014) suggests, from examples of resistance.

Indeed, following from the strategy literature (e.g., Oliver, 1991; Scott & Davis, 2006), resource strengths and institutional standing/status may buffer some universities from turning into outright academic capitalist/knowledge-learning regimes. In this way, some SOIs could embrace market-mentalities and structure to advance science to compete and make money, but others may draw on sources of funding (e.g., from private donors and philanthropists) that provide distancing from market motives and government interests.

Such criticism notwithstanding, academic capitalism helps us conceptualize the *locus of action* of organizational change and adaptation. Pieces of the academic enterprise, the SOIs as organizing units, can pursue independent actions for competition and money. While the theory suggests increasing levels of administrative and managerial authority and oversight, it also indicates entrepreneurship—risk-taking in investments and pursuits—throughout the many layers of organizational hierarchy. The actions of semi-autonomous, entrepreneurial units are related to the people affiliated with them and whose interests undergird organizational change (DiMaggio, 1988). The theory indicates social relations somewhat at odds with prior understandings of campus-level governance. Administrators and faculty members oft-seem to oppose one another: administrators want to maximize institutional prestige and revenues, and faculty members want money but to purchase autonomy to pursue their own research agendas. But within the context of academic capitalism we may find campus leaders and faculty working together when their interests in resources and the advancement of scientific knowledge align. That is, some administrators (and thus institutions) and faculty share in common goals of increasing resources, visibility, and prominence, and at this nexus, faculty members could gain privileged access to administrative and financial authority.

Academic capitalism offers understandings of professionalization in the knowledge-economy. As concepts of professionalization suggest, groups of professors could seek to form a niche within the academic labor market (Larson, 1979). Claims of specialized knowledge and expertise can situate them within "exclusive shelters" (Brint, 1994, p. 23) of legitimacy and rewards. The development of new organizational structures, which could certify status/standing in academe, may prompt resistance on campus but not always a division between administrators and faculty. When they mix resources, for example from institutional and school or department budgets, they can benefit from changes that lead to additional external resources.

As Abbott (1988, p. 2) suggests, "interprofessional competition" and "jurisdiction disputes" can incite conflict within professions. Professors in STEM can demonstrate their relevance to external funders, allowing them to professionalize in new, nascent disciplines and fields and SOIs. Ties to resource-providers have often codified professions, in fields such as medicine, law, and higher education (Slaughter & Silva, 1983; Wolfle, 1972). Institutions may seek to stimulate the academic heartland (Clark, 1998), yet, within the context of academic capitalism, the locus of change and adaptation may occur at the level of academic scientists and administrators who each and together introduce, champion, and finance organizational innovations.

Yet institutions vary in their competitive positioning. As academic capitalism suggests, there are winners and losers within the stratified social space of higher education. Slaughter (2014) observes that elite private AAU institutions have dense layers of network connections, by way of trustees, to patenting firms that likely exceed those of most elite public AAU institutions. Among the private AAUs, MIT has more and thicker ties than, say, Tulane University. Thus we begin to see where institutional theory, resource dependence theory, and academic capitalism intersect. Together they indicate conditions under which institutions aim to compete: from positions of varying resources and elite statuses. In the next section I draw on the three theories to build a conceptual model that explains SOIs as strategic responses.

Quadrants of innovation model

When they are brought together within a conceptual framework, institutional theory, resource dependence theory, and academic capitalism can account for variation and emergence of SOIs. Recall that in Chapter 2, SOIs may be situated within a matrix form of organizational hierarchy. In this section I draw on the three theories to describe the political economy of SOIs. Then I depict the core theoretical construct of this thesis: innovation in relation to institutionalization and resources.

Institutional theory explains the dense layer of academic departments and, increasingly, interdisciplinary schools. Academic structure can change (Gumport, 2002; Stephan, 2012) but usually remains stable. It represents embedded commitments to core disciplines and fields, to internal and external constituents who influence institutional legitimacy, and to the budgets that resource the system of units and subunits on campuses. The centers and institutes that encircle the core can find some explanation in institutional theory: it could be the drift of the institution toward external funding sponsors that accounts for variation and emergence of these particular SOIs.

In comparison to institutional theory, resource dependence theory offers conceptual clarity in three ways. First, it suggests that structural variation of the entire matrix can be utilized to balance power relations between autonomy-seeking institutions and environmental control. Second, it further suggests the internal allocation of money across SOIs' formal (e.g., horizontal and vertical) and informal (e.g., network) links in proportion to SOIs' success in capturing external money. Finally, it suggests ways in which the various units and subunits—the institution as a whole—could buffer from academic capitalism. In other words, it takes money to buffer from having to take risks in markets (Morphew, 2009).

Change can occur not only through SOIs but also within them. Academic capitalism, which resource dependencies can mediate, accounts for external flows of money, research, and people by way of the academic core of departments and schools. The full ascendancy of academic capitalism may yet to take root in some SOIs, but does augur what may likely come. Perhaps most importantly, academic capitalism explains the links among SOIs on campus and between SOIs and external stakeholders. Through their entwinement in networks SOIs form at interstices of STEM fields and organizations and thus contribute to "new circuits of knowledge" that aim to open funding streams (Slaughter & Rhoades, 2004, Slaughter, 2014).

In developing a conceptual model for thesis, it may help to visualize and unpack the dynamics that shape SOIs. Figure 1 presents a quadrants of innovation model. Here, innovation—parturition of SOIs—is depicted in relation to institutionalization and resource position. As the image suggests, there are four quadrants of innovation. Quadrant I features universities that are "high institutionalization" based on historical embedding and clout in the AAU and "resource strengthened" because of increases over time in federal R&D funding. Institutions innovate from an overall position of strength with both status/standing and money to change and adapt. Quadrant II features universities that are “high institutionalization” and “resource threatened” due to decline or relatively minimal or flat growth in federal R&D funding over time. Such a resource position, in this case, can compromise institutionalization and lead to innovation for money to protect or regain status/standing. Quadrant III features universities that are “low institutionalization” and “resource threatened.” Though members of the AAU, they operate from the margins of the field and thus innovate to demonstrate their belonging and support efforts of ascendancy. Quadrant IV features universities that are “low institutionalization” as recent entrants in the AAU and “resource strengthened” with increasing success in federal R&D funding. The motivation for innovation, within this quadrant, may be pursuits of proving status/standing as elites.

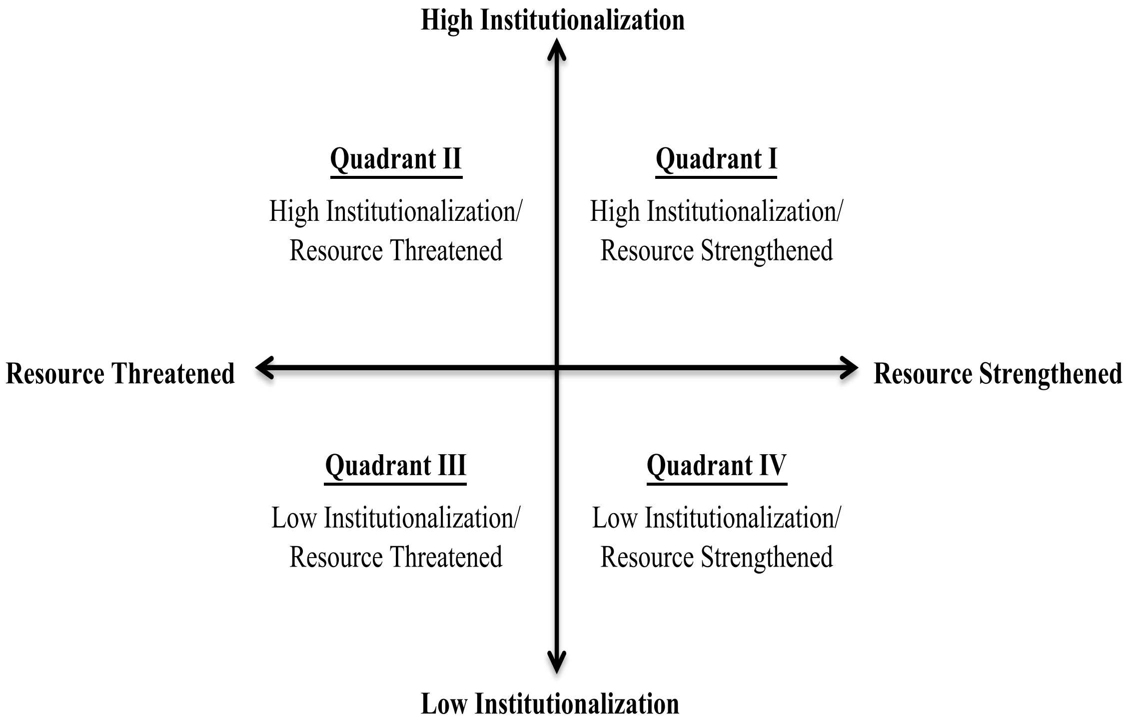

Figure 1. Quadrants of innovation model.

Though not depicted visually, academic capitalism accounts for SOIs as platforms for competition and profit-seeking. Without doubt universities can fall in between quadrants of innovation, but they go beyond the scope of this thesis. While the conceptual model suggests motivations and conditions that shape SOIs, it does not indicate precisely what universities within the quadrants are doing in this arena. For instance, we know little empirically about whether the low institutionalization and low resource (Quadrant III) universities emulate the high institutionalization and high resource (Quadrant I) universities. The former could seek strikingly new ways to prove themselves, and the latter might pursue conservative approaches to innovation or perhaps "cash in" status/standing and resources to move in bold directions. What is more, high institutionalization and low resource (Quadrant II) universities could copy their high resource (Quadrant I) counterparts, but low institutionalization and high resource (Quadrant IV) might draw on strong federal R&D funding to buffer some from integration of field-influences with SOIs. Thus the conceptual model points toward an empirical approach of comparative case analysis; however, whether data will reflect such scenarios remain unclear.

Summary

To build a theoretical framework for this thesis, I draw on institutional theory, resource dependence theory, and academic capitalism as explanations for SOIs within and across research universities. Institutional theory suggests that organizations transition into institutions when imbued with value and meaning beyond their technical efficiency, achieving stability in structures that meet the taken-for-granted beliefs and resources commitments of stakeholders. Resource dependence theory explains emerging organizational structures that help institutions diversify funding streams across numerous sponsors and thus increase managerial authority and discretion. Academic capitalism accounts for movements of universities to markets that shift the focus of higher education away from the public good and toward profits and alter the structures, behaviors, and social relations on campuses. Though they differ in important ways, together the three theories explain the various dimensions of matrices within which SOIs are situated. They also inform a quadrants of innovation model of SOIs by institutionalization and resources, pointing toward an empirical approach for comparative case-study analysis.

CHAPTER 4

RESEARCH DESIGN

This thesis presents a multiple embedded case study of SOIs within and across research universities. Institutional researchers and analysts tend to favor the single case-study approach. They typically engage the whole organization (Kraatz & Block, 2008; Perrow, 1986; Selznick, 1949, 1957), by which to detail its distinctiveness (Clark, 1972). A multiple case analysis somewhat limits the investigation into individual sites, but can lead to robust empirical conclusions (Miles & Huberman, 1994; Yin, 2014). It may, in scope and scale of data collection and analysis, help us re-evaluate theoretical propositions and build conceptual models to explain social phenomena. The emphasis on multiple cases supports this work's aim to assay SOIs at research universities and pinpoint the external and campus-level influences on the emergence of SOIs. Such a research design makes possible the study of variation: why institutions within a field, where they receive comparable mimetic, normative, and regulatory cues, differ in their change and adaptation (Clark, 1983).

In this thesis, the case is the continua of SOIs *within* a single institution. The multiple cases, then, are SOIs at one institution for comparison to SOIs at other institutions. Since the focus of the study pertains to emerging organizational forms on campuses, the cases can be described as "embedded." The embedded case design, Yin (2014) observes, "can often add significant opportunities for extensive analysis, enhancing the insights into the single case" (p. 56). To focus on SOIs, though subunits of analysis in relation to the campus-level, can help us learn about them as distinct sets of organizational developments. But they can also tell us about their home institutions' broad movements and dynamics of change. As one embedded case of SOIs is compared to other embedded cases of SOIs, this thesis constitutes a multiple embedded case study design.

In this chapter, I reiterate next the core research questions that guide this study's analysis. The questions establish the variables of interest—SOIs, institutionalization and resource position within a field, and campus-level factors—from which the empirical indicators for the study are distilled. Then I outline the sampling strategy for STEM fields and disciplines, research universities in the Association of American Universities (AAU), SOIs, and individual participants. I conclude with a discussion of procedures for data collection, analysis, and trustworthiness of the study.

Research questions

As the research literature (Chapter 2) and guiding theoretical framework (Chapter 3) suggests, continua of possibilities exist for universities that adapt to advance science. Together literature and theory indicates a range of potential centers, institutes, schools, and departments that constitutes what I call SOIs. They can interconnect with each other in matrices and with the external environment to facilitate flows—*fluidity* and *continuity*—of research, money, and people. While such a conceptualization may help us anticipate the various forms and underlying drivers of change on campuses, it leaves us with several empirical gaps.

To reiterate the core knowledge gaps in this arena, it remains unclear which specific SOIs universities develop and around which particular niches in STEM. We continue to lack understandings of how universities' resource positioning in federal R&D funding influences innovation in the research core (e.g., innovation from strengthened or threatened resource positions). Moreover, we know little about how universities' institutionalization within a field, of long-term prominence or recent entrance/ascendancy, interacts with their resource-bases to shape their set of SOIs. And we have thus far missed opportunities to study organizational innovation in higher education at the "ground level," where administrators and faculty members are entwined in processes and institutionalization of change and adaptation on campuses.

In light of these lacunae, three questions guide this thesis:

(1) What is the nature of variation of STEM-centered organizational innovations (SOIs) among research universities?

(2) How does the external environment influence the emergence of SOIs?

(3) How does the institutional context influence the emergence of SOIs?

Each question suggests particular variables of interest and related indicators, and it may help to operationalize its respective key concepts and tease-out the empirical implications.

For research question one (RQ1), "nature of variation" refers to continua of SOIs within and across research universities. The guiding theoretical framework suggests the permeability of organizational boundaries and the resulting manifestation of various structural forms that aim to establish fit and equilibrium for viability. Variables of interest here are qualities and characteristics of SOIs on campuses. To indicate them, the structure, purpose, business model, and scientific niches of SOIs are considered. SOIs could vary across institutions based on the extent to which they are situated in matrices on campuses, and thus to assay the degree of interconnectedness of SOIs at their home institutions, formal organizational hierarchies are utilized. Within an increasingly competitive environment in science and for resources, the guiding theoretical framework suggests, strategic approaches could reflect some homogeneity. The cross-comparative approach, assaying SOIs at multiple universities, can illuminate differences in sets or portfolios of emerging organizational forms among campuses.

For research question two (RQ2), “external environment” entails federal R&D funding and the AAU that can together underpin the parturition of SOIs. The main variables of interest here are institutionalization and resource position of universities in a field. Age, from an institutional perspective, can factor into status/standing and indicate institutionalization. Within the AAU, institutions vary in how deeply situated they are based on designation as founding or early members or later, more recent entrants. The year of membership—an initial certification of prestige—in the AAU serves as one indicator of institutionalization. As the guiding theoretical framework suggests, success in federal R&D funding covers the largest share of scientific research and brings with it national visibility and prestige. Resource levels over time can thus embed universities within a field, influencing status/standing. A key indicator, then, becomes a university’s history of scale-adjusted federal R&D dollars. Yet resource dependencies may mediate strategic change, inspiring even long-term AAU members to innovate to compete to remain viable. Thus the *fluctuation* of federal R&D funding, indicated by median percent change in federal R&D funding over time, constitutes a third indicator by which to assess innovation from strengthened or threatened resource positions.

Research question three (RQ3) asks about "institutional context," evoking processes and drivers of adaptation within universities: history, politics, money, and people. Context matters, the guiding theories suggest. Those relatively new to a field and with threatened resources may adopt in full field-driven changes and adaptations; founding members and those with diverse, robust resources may initiate institutional changes, integrate change as balanced with autonomy, refuse to adopt, or reflect some inertia. RQ3, as theoretically informed, offers an opportunity to study the locus of action, the administrators and faculty whose relationships and resources may underscore change and adaptation and its formalization on their campuses. To indicate the variables of interest here (campus dynamics pertaining to history, politics, money, and people), the structural, operational/procedural, and cultural-cognitive dimensions of campuses are considered.

The three research questions assume the importance of science and money to elite research universities. In the next section, I outline the sampling of STEM fields and disciplines, institutions, SOIs, and individual participants. The sampling criteria at each level of the research design suggest a particular aim: to follow the flow of money from the federal government to fields and disciplines to universities to campus units to faculty and administrators.

Sampling

STEM fields and disciplines

As Figure 2 shows, the federal government prioritizes its awarding of R&D funding to private industry, national laboratories, universities and colleges, nonprofit institutions, and states and local governments. Each year private industry receives nearly half of these funds (48%), almost twice as much as the second largest recipient, national laboratories (26%), and three times more than universities and colleges (18%). Together the combined annual share for nonprofit institutions and state and local governments is 5%. While universities and colleges do not receive the most federal R&D funding, their outlay nonetheless constitutes a strong incentive for them. From the start of the Bayh-Dole era in 1980, when the process for universities to patent discoveries and inventions from federally funded research was streamlined, to the funding climate in 2014, the median federal R&D funding to universities and colleges in 2014 constant dollars was $29 billion.[24]

[24] The calculation was adjusted for inflation using the Higher Education Price Index (HEPI). Some higher education researchers and analysts prefer to use the Consumer Price Index (CPI). Others find some limitations with the CPI, for, advocates of HEPI suggest, the formula does not accurately capture cost increases in the higher education sector (Griswold, 2006). HEPI can thus allow for a more conservative approach to adjusting financial data for inflation. This thesis follows examples in the research literature that utilizes HEPI as part of empirical analyses of resource contexts that shape academic and administrative structure (e.g., Gumport, 2002; Gumport & Pusser, 1995).

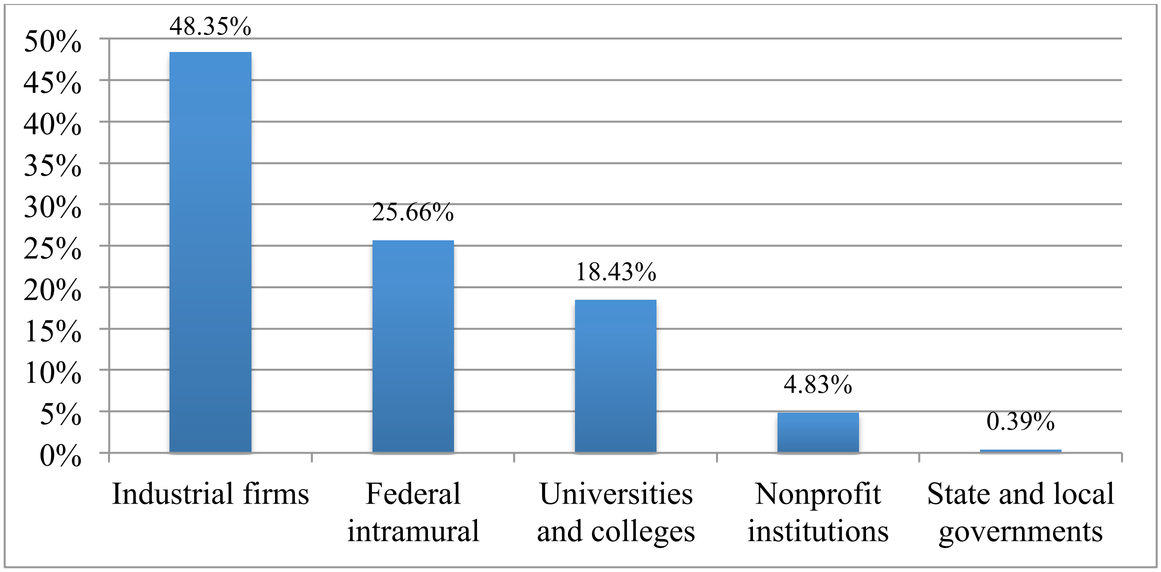

Figure 2. Median percent of federal R&D obligations, by U.S. performers of research, 1955-2014. *Source:* National Science Foundation, *Federal R&D Obligations*.

Disproportionate federal R&D funding to universities and colleges flows to STEM fields. As Figure 3 shows, the life sciences receives the largest share of federal R&D to universities and colleges (66%). The physical sciences receives the second largest share (10%), but suggests a downward trajectory since the 1990s when biomedical outlays within the life sciences begin to increase. Engineering receives about 8% of total allocations, and in comparison to the physical sciences it demonstrates a pattern of growth that coincides with the rise of biomedical engineering in the late 1990s and early 2000s. Also noteworthy is funding for mathematics and computer sciences, which has a 4% share and trends slightly upward in recent years around national interest in cyber security, data sciences, and computing technology. We can interpret these descriptive data as the basis for competition across fields. They suggest some zero-sum games (e.g., growth in engineering vs. decline in physical sciences) around which institutions position. Additionally, they suggest competition within fields where institutions seek, even in low funded areas, whatever they can get.

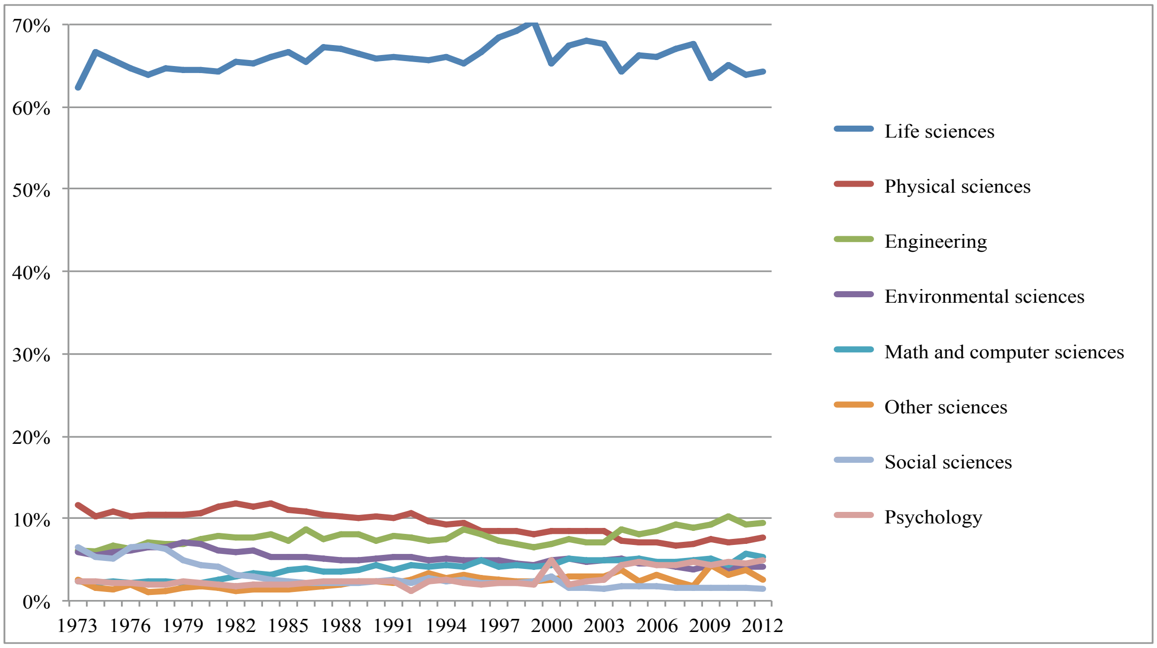

Figure 3. Percent of federal R&D funding to universities, by field, 1973-2012. *Source:* National Science Foundation, *Survey of Federal Funds for Research and Development*.

To specify the funding priorities within STEM fields, it may help to consider R&D expenditures at universities and colleges by discipline. Figure 4 indicates three clear, top priorities on campuses reported here in order: medical sciences, biological sciences, and, though in decline, agricultural sciences.[25] Together these disciplines, which constitute the life sciences, receive over half of all R&D expenditures. They are

[25] From the perspective of the AAU, federal R&D funding for agricultural sciences does not "purchase" prestige. As Carey (2014) suggests, federal allocations for agricultural sciences is not always awarded competitively, and thus institutions with strong funding in this arena must still prove themselves by winning external resources to support research in other disciplines and fields, especially in the biomedical sciences.

targets of R&D as they meet the interests of the public and national policy-makers in promoting human health and economic development, and they are profitable areas for private industry. Though not necessarily a surprise, R&D expenditures in physics and chemistry have declined amid general patterns of fading from policy and funding prominence after the World Wars.[26] Of note, bioengineering/biomedical engineering has received its inaugural outlay as a discipline in 1997: in less than 20 years it has grown and now constitutes 1% of all R&D expenditures on campuses.

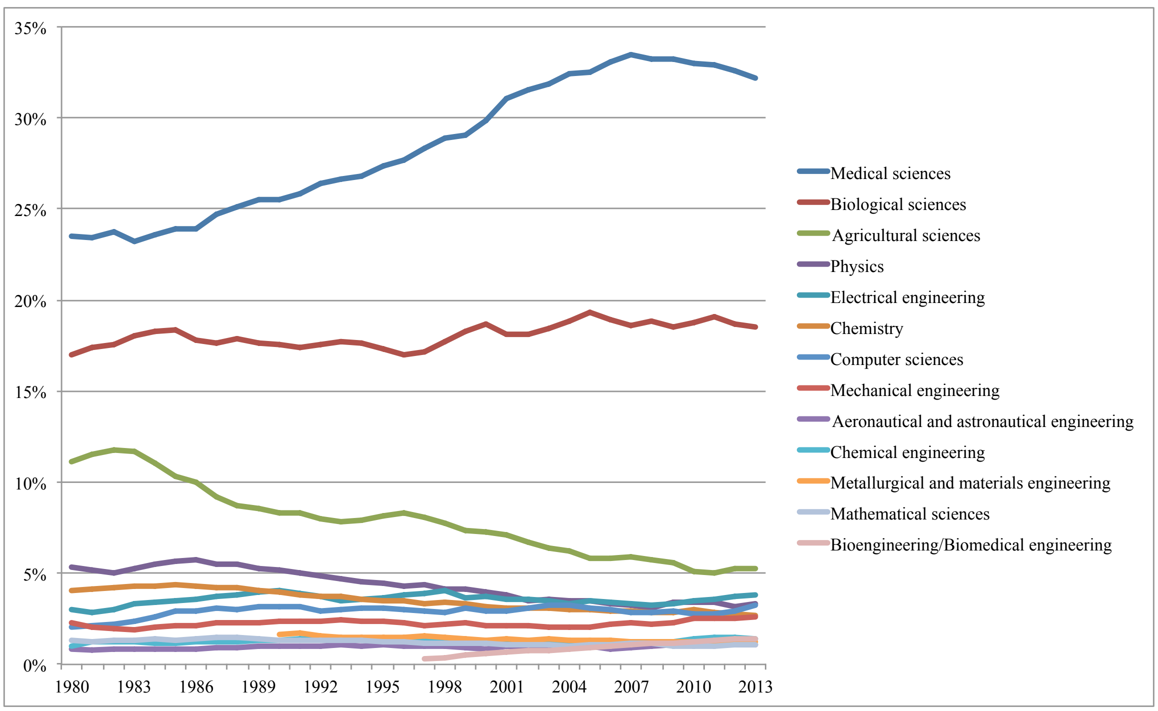

Figure 4. Percent of R&D expenditures at universities and colleges, by select disciplines, 1980-2013. *Source:* National Science Foundation, *Survey of Research and Development Expenditures at Universities and Colleges*.

[26] Materials science has typically been viewed as a "replacement" for physics (Leslie, 1993). While chemistry's R&D expenditures seems to decline over time, it is still associated with strong activity in the arenas of patenting and start-up firms.

As patterns of federal R&D funding and R&D expenditures at universities and colleges suggest, life sciences in general and medical and biological sciences in particular are long-standing priorities. The amount of money and research activity in these areas indicates robust incentives for structural change in universities. Indeed, SOIs could develop around the fields and disciplines where the most funding goes. For the sampling of fields and disciplines, this analysis mainly focused on the life sciences and medical and biological sciences. While it may seem that there are relatively low incentives for structural change in other fields and disciplines, money is money. Recall that engineering typically receives an 8% share of federal R&D funding, and the discipline of metallurgical and materials engineering, an expenditure category since 1989, receives 1% of R&D expenditures at universities and colleges. Scarcity—or resource constraints by field and discipline—may prompt SOIs. But engineering and many of its disciplines also carry national prominence for their technological developments that can be harnessed to advance science in other disciplines and fields (e.g., biomedicine). This analysis thus considered all STEM fields and disciplines, narrowing the selection based not on *a priori* criteria but niches around which the sampled institutions position.

AAU institutions

To gain and uphold membership in the AAU, the 60 U.S. institutions tend to homogenize. They are not identical (for instance, compare the University of Oregon to California Institute of Technology, or University of Kansas to Brandeis University), but share some common, fundamental characteristics. The Carnegie 2010 classification lists AAU members as “very high research” universities. They produce disproportionate shares of doctoral degrees (especially in STEM), have some of the most nationally recognized faculty based on research accomplishment, awards, and membership in prestigious groups such as the National Academy of Sciences, and are highly competitive in securing external grant funding. Many have pursued—and have actually made money from—patents, technology transfers, licenses, and spin-offs and start-ups. The AAU touts its members' federal R&D funding levels that constitute more than half of all outlays to colleges and universities (AAU Facts & Figures, 2014). We should be skeptical of such self-interested claims; however, these claims have some validity: even in raw, unadjusted dollars, co-founding AAU member Johns Hopkins University receives more money than any other university in the U.S. But within the AAU, institutions vary by their degree of institutionalization (e.g., historical embedding) and resource positioning. It may be helpful to consider the broad composition of the field.

Figure 5 presents a scatterplot that shows how the 60 current U.S. members of the AAU have faired over time in institutionalization and resource position. Institutionalization, as operationalized in this chapter, had two indicators: "age" in year of entry into the AAU and federal R&D funding (e.g., median federal R&D funding per FTE undergraduate and graduate enrollment, in 2010 HEPI-adjusted constant dollars). Resource position was determined by fluctuation in funding: median percent change in federal R&D over time. As the color key for percent change depicts, institutions within the orange to green range increased their shares of federal R&D funding, while those in shades of red experienced low growth, flattening, or decline.

To understand the distribution of institutions in the field by research funding levels, the figure shows the median federal R&D per FTE enrollment (for undergraduate and graduate students) for the period 1975 to 2010 (X-axis). The year 2010 serves as a cut-off, for it helps to capture a "lag" effect: organizational adaptations targeted for observation in this thesis in 2014 likely had antecedents in preceding years. The start date of 1975, though some data were available for federal R&D obligations before then, accommodated for scale-adjusting federal R&D funding with readily available longitudinal enrollment data for these institutions. AAU entry year (Y-axis) spans the very first members who formed the field in 1900 and also the most recent entrant, Boston University, which gained access in 2012. Membership in the AAU hinges on *prior* success in federally funded science research and *continued* growth. Thus, including Boston University from 2012 is helpful, for admittance into the field comes from funding levels in previous years.

The majority of institutions are clustered toward the right of the figure, with overall positive trends in federal R&D funding. It may, however, help to consider a nuanced example of variation in institutional positioning. For example, Georgia Institute of Technology (Georgia Tech) joined the AAU in 2010, had $10,000 in median federal R&D funding per FTE enrollment, and had a 30% increase in federal R&D funding over time. University of Chicago was a founding member of the AAU in 1900, had $20,000 in median federal R&D funding per FTE enrollment, and had an 8% decrease in federal R&D funding over time. Georgia Tech, one of the two newest AAU entrants in recent years, exceeded the AAU median of $9,000 for federal R&D funding per FTE enrollment but far surpassed the AAU median of an 8% increase in funding over time, while University of Chicago had long-standing prominence in length of membership and scale-adjusted dollars yet appeared resource threatened in being well below the AAU's median in percent change of federal R&D funding. The institutions are both elite yet differ some in their contexts for organizational change and adaptation.

Of the 60 U.S. AAU institutions, 35 are public. This thesis focused further on the 25 public universities with campus-access to medical schools. As compared to private institutions, public universities have capacity to grow in infrastructure for teaching, research, and service (Brint, 2005, 2007). They have a size and scale advantage, though private institutions are known for their endowment wealth and nimbleness. Furthermore, delimiting to public institutions allows for somewhat comparable cross-case comparisons among these universities. The sampling strategy controlled for "control" because any observed difference in institutions might otherwise be attributed to private or public status rather than to the quadrants of innovation (based on institutionalization and resource positioning). Additionally, it can be more difficult to gain access to private institutions as compared to public colleges and universities, and thus there have been conceptual and empirical reasons to sample from AAU public institutions.

While the aim here was not to study SOIs in medical schools, it was important to consider those with campus *access* to medical programs at their home institutions. They can be networked to compete for Life sciences/biomedical money from the richest funding stream for STEM fields and disciplines. Also, the structural characteristic of a medical school is common among many of the "very high" and "high" research universities in the U.S., which may make the research findings of this study somewhat applicable to other institutions.

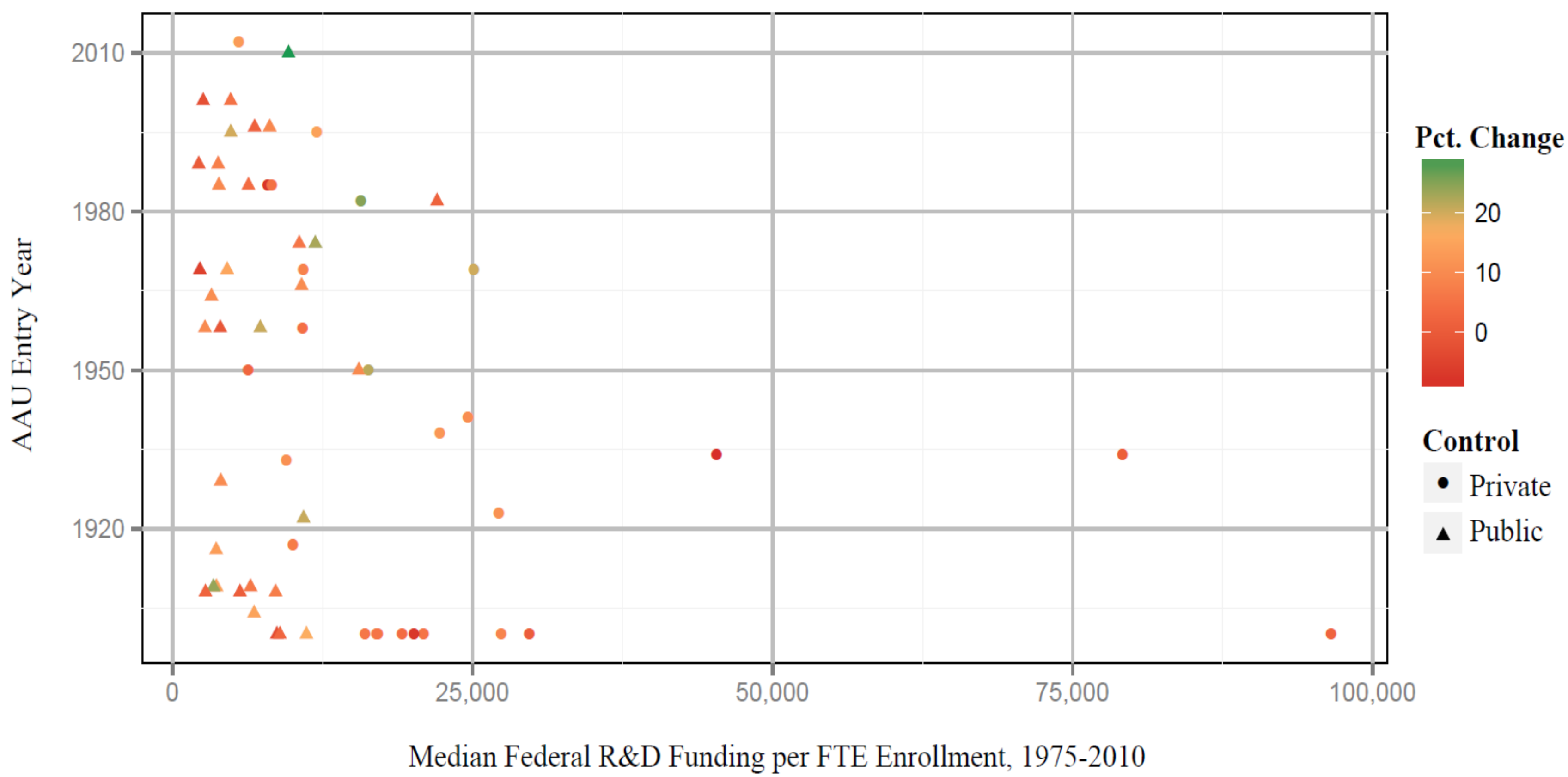

Figure 5. Current AAUs, by entry year, federal R&D funding, and percent change in federal R&D funding. *Sources:* AAU, NSF, & NCES. *Notes:* Median federal R&D funding is reported in 2010 constant dollars based on HEPI. FTE enrollment was calculated by adding full-time enrollment to one-half of the number of part-time enrollment. Percent change reflects the median percent change over each of five years from 1975 to 2010.

Figure 6 presents a scatterplot of the 35 public AAU institutions, aiming for a closer look at select universities than the broad overview of Figure 5 has offered. It shows which institutions offer SOIs campus-access to medical programs, and it also maps institutions by (1) median percent change in federal R&D funding (X-axis) and (2) number of years in the AAU as of 2014 (Y-axis). The median percent change for the 35 public AAU institutions was 9% (1% higher than the overall AAU average of 8% growth when private institutions were included), and the median length of membership, of age in the AAU, was 53 years (e.g., entrance in 1961). As the figure shows, the X- and Y-axes cross at the 9% and 53-year mark, forming quadrants of innovation by which public AAUs can be grouped.

Recall that from Chapter 3 (Figure 1), universities may fall each into one of four quadrants of innovation: (1) high institutionalization/resource strengthened; (2) high institutionalization/resource threatened; (3) low institutionalization/resource threatened; and (4) low institutionalization/resource strengthened. Numerically, in Figure 6, "high institutionalization" referred to institutions that joined the AAU between 1900 and 1957 and had median federal R&D per FTE enrollment around or above the public AAU group median of $5,980 (in 2010 constant dollars). "Low institutionalization" referred to institutions that joined the AAU between 1958 and 2014 and had median federal R&D per FTE enrollment around or below the public AAU group median. "Resource strengthened" referred to institutions with upward trends in federal R&D funding per FTE enrollment, with a median percentage change greater than the public AAU group median of 9%. "Resource threatened" referred to institutions with downward or relatively small growth trends in federal R&D funding per FTE enrollment, with a median percent change lower than the public AAU group median.[27]

The sampling of institutions consisted of selecting one university per quadrant. Four universities were largely representative of their groupings based on providing SOIs access to medical schools on their campuses and approximating the medians for institutionalization (age and scaled-adjusted federal R&D funding) and resource position (median percent change in scale-adjusted federal R&D funding). As the orange coloration indicates in Figure 6, they were:

- University of Virginia (UVa) from Quadrant I: High Institutionalization/Resource Strengthened;
- University of Illinois at Urbana-Champaign (UIUC) from Quadrant II: High Institutionalization/Resource Threatened;
- Stony Brook University (SBU) from Quadrant III: Low Institutionalization/Resource Threatened; and
- University of Florida (UF) from Quadrant IV: Low Institutionalization/Resource Strengthened.

[27] For private AAUs, median "age" was 64 years (entry date of 1950), median federal R&D per FTE enrollment was $9,227, and median percent change in federal R&D per FTE enrollment was 7.5%. In comparison to public AAUs, private AAUs were longer-standing members in the field (e.g., older) by seven years, richer on average in federal R&D funding by $3,248, and had slightly less growth, by 1.5%, in federal R&D over time. Such patterns suggest increases in federal R&D to public AAUs over time, though the public AAUs tend to have less engrained status/standing in the elite field.

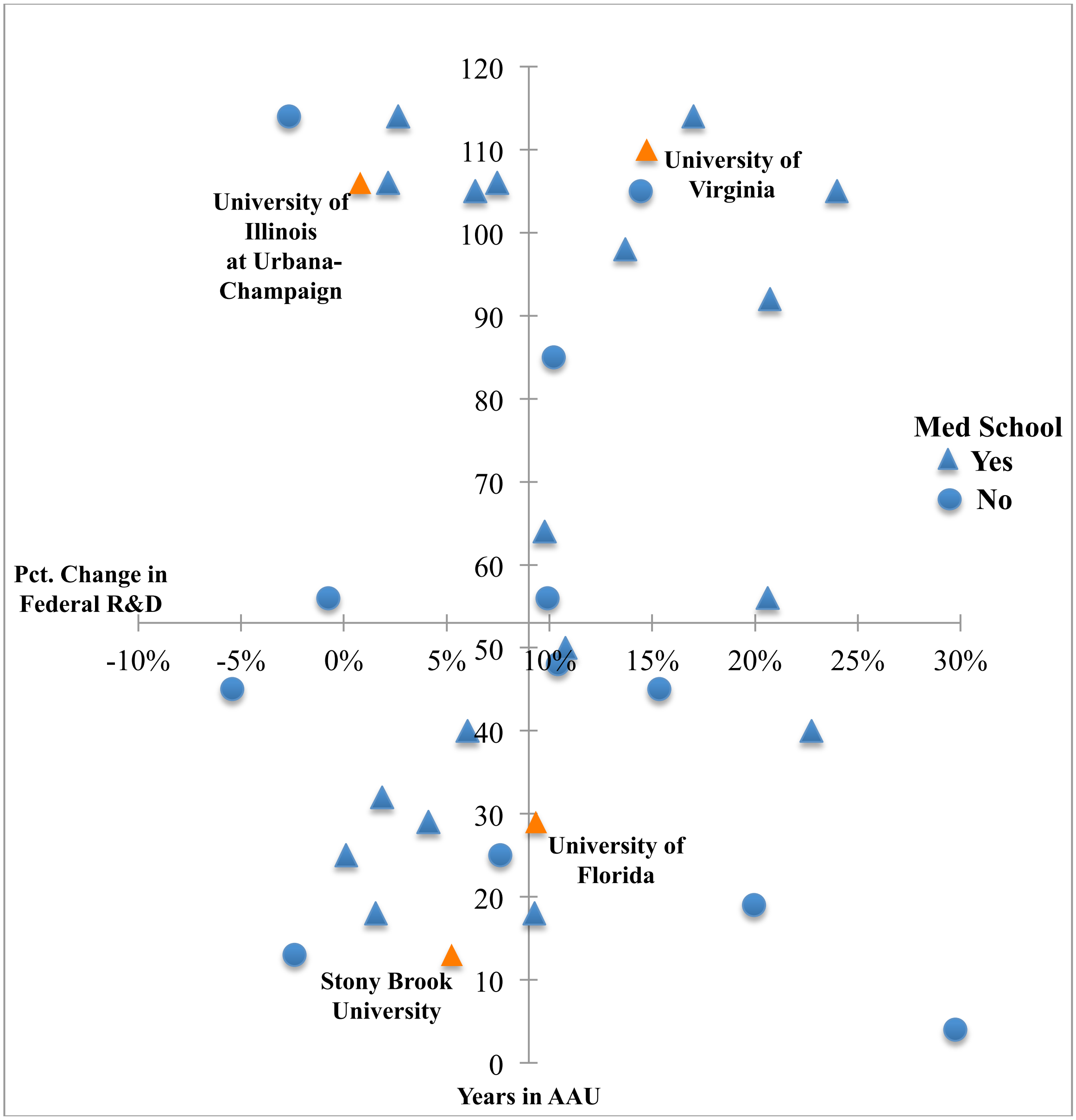

Figure 6. Public AAUs, by years in the AAU and percent change in federal R&D funding. *Sources:* AAU, NCES, and NSF. *Notes:* Orange coloration indicates institutions sampled in this thesis. Years in the AAU were calculated by subtracting the official AAU entry year for each institution from 2014. Percent change in federal R&D was calculated as follows: first, federal R&D funding per FTE enrollment was tallied for each institution for 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010; second, the funding amounts for each institution were adjusted for inflation with HEPI and converted to 2010 constant dollars; third, the percent change in funding was calculated for each institution in each five-year segment from 1975 to 2010; finally, the median percent change was calculated as a proxy for an institution's resource position over that time frame. Medical school status was determined from its location on or off campus.

A summary of each institution and its SOIs is presented in Chapter 5, but it may be helpful to highlight a few descriptive metrics:

- *Quadrant I.* UVa joined the AAU in 1904, had $6,805 in median federal R&D funding per FTE enrollment, and had 15% growth in federal R&D funding. Its current FTE enrollment is 22,275 students.[28] In relation to its quadrant, UVa had been in the AAU for 110 years and was thus 15 years above the group median (e.g., 95) and also hit the precise group median for research funding growth.
- *Quadrant II.* UIUC joined the AAU in 1908, had $5,625 in median federal R&D funding per FTE enrollment, and had rather small growth over time in federal R&D funding (1%). Its current FTE enrollment is 43,030 students. Relative to its quadrant, UIUC hit the group median for age (106 years) and was about one percentage point below the group median for resource position (2% growth).
- *Quadrant III.* SBU joined the AAU in 2001, had $4,489 in median federal R&D funding per FTE enrollment, and had 5% growth in federal R&D funding. Current FTE enrollment at SBU, analogous to UVa's size, is 22,094 students. In relation to its quadrant, SBU's age (13 years) was about 12 years younger than the group median (25 years) and its resource position (5% growth) was somewhat stronger than the group median (2% growth). With some variation among institutions in the quadrant, SBU

[28] "Current" FTE enrollment is based on figures for 2013, the most recently released, publicly available data from the National Center for Education Statistics' Integrated Postsecondary Education Data System.

approximates the metrics for sampling and exhibits a solid, though not quite mathematically perfect, selection.

- *Quadrant IV.* UF joined the AAU in 1985, had $3,866 in median federal R&D funding per FTE enrollment, and had just less than 9.5% growth in federal R&D funding. The largest institution in the study, UF's current FTE enrollment is 46,184 students. As depicted in Figure 6, Quadrant IV is rather diffuse and reveals some considerable variation among institutions, precluding straightforward selection of *the* representative university. Such difficulty notwithstanding, UF's age (29 years) was within close range of the group median (35 years). Its resource position (9.4% growth) was, however, 3.7% less than the group median (13.1%), which suggested a strong funding trajectory albeit one slightly more moderate than others'.

To address ways in which the sampling strategy may influence the empirical results reported in this thesis, it may be helpful to consider the relative "distance" between the selected institutions across quadrants. Of particular note, in the figure above, UVa from Quadrant I and UIUC from Quadrant II are farther apart on the numeric indicators than SBU from Quadrant III and UF from Quadrant IV. The proximity between SBU and UF suggests that observations about these two institutions may reflect more similarities than differences. Greater variation, that is, may exist between the average Quadrant III and Quadrant IV institutions than what can be ascertained here. This thesis may, such considerations notwithstanding, still provide an initial starting-point to highlight ways in which distinctive institutionalization and resource contexts shape SOIs.

Figure 7 reiterates the sampling of institutions in light of the guiding conceptual model outlined in Chapter 3. For this thesis the institution was not the unit of analysis, but sampling, as theoretically informed, helped to contextualize the nature and emergence of SOIs (e.g., the cases). In the next section, the sampling of SOIs is presented.

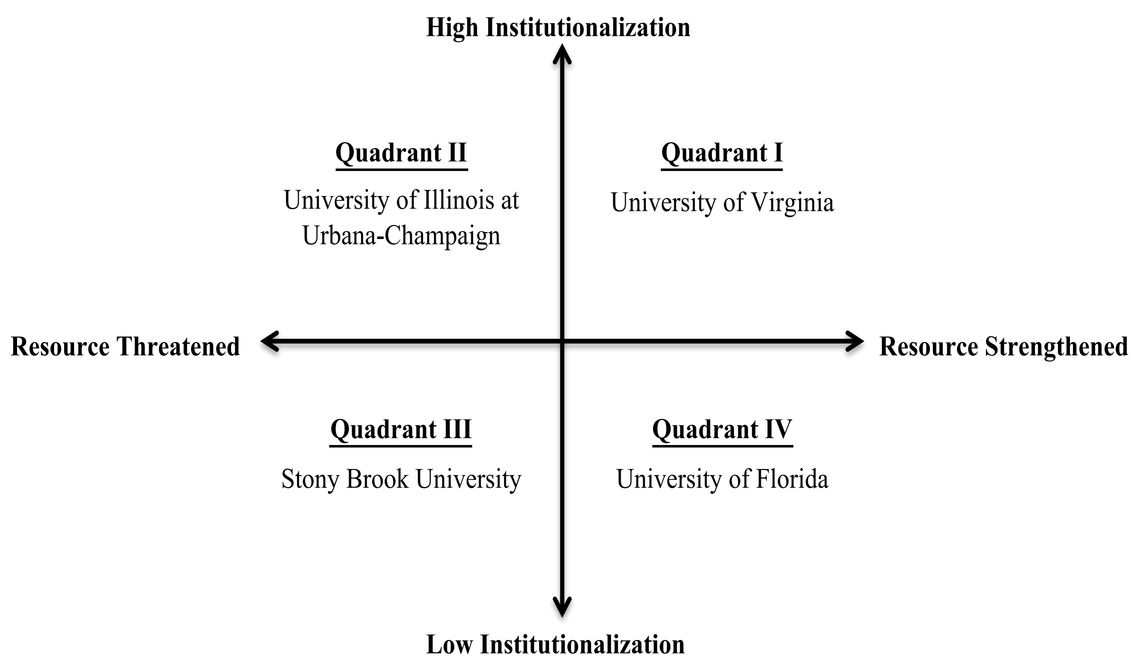

Figure 7. Sample of public AAUs, by quadrant of innovation.

STEM-centered organizational innovations (SOIs)

A set of criteria was used to sample SOIs within and across the four AAU institutions. For inclusion in the study, the SOIs had to have been formed between 2000 and 2014 to ensure an adequate sample of the most recent set of units to date. Then they had to meet the following parameters: they were in their names called centers, institutes, schools, or departments; engaged particular strands of science (e.g., nanotechnology, pharmaceuticals, biomedicine, computing, etc.); served the research mission of their institutions; and had articulated goals, affiliated personnel (e.g., directors, faculty members, administrative staff, etc.), and, perhaps most importantly, capacity to receive and allocate money. They also had publicly available websites, which led to their initial consideration. Application of the sampling criteria for SOIs at one institution (e.g., UVa) was replicated for SOIs at the other institutions (e.g., UIUC, SBU, and UF). Such replication allowed for consistency, suggesting that any variation observed within and across campuses in this study might largely come from the nature of the social phenomena rather than from the research design per se.

With the criteria for inclusion now established, it may help to clarify the steps that led to the sampling of SOIs. First, institutional, college, and/or school (e.g., College or School of Engineering) websites were searched to identify centers and institutes in STEM. Second, college websites were searched to identify schools and/or departments. Finally, individual websites for centers, institutes, schools, and departments were checked to verify that the organizational units met the criteria for sampling. As Table 2 shows, the sampling process yielded 35 SOIs across the four institutions: nine at UVa, nine at UIUC, nine at SBU, and eight at UF. I present summaries of the cases, of each institution's set of sampled SOIs, in Chapter 5.

Table 2. Sample of SOIs, by institution and founding date.

UVa	UIUC	SBU	UF
UVa Center for Global Health (2001)	School of Molecular and Cellular Biology (MCB) (2000)	Center for Developmental Genetics (2000)	Department of Biomedical Engineering (2002)
NSF Industry/University Cooperative Research Center for Lasers and Plasmas (2002)	School of Integrative Biology (SIB) (2000)	Center for Infectious Diseases (2000)	Nanoscience Institute for Medical and Engineering Technology (NIMET) (2005)
Institute for Nanoscale and Quantum Scientific and Technological Advanced Research (nanoSTAR) (2004)	Center for Nanoscale Science and Technology (CNST) (2001)	Center for Structural Biology (2000)	Emerging Pathogens Institute (EPI) (2006)
SHANTI (2008)	Department of Bioengineering (2003)	Department of Biomedical Engineering (2000)	NSF Industry/University Cooperative Research Center for High-Performance and Reconfigurable Computing (CHREC) (2007)
UVa Center for Wireless Health (2009)	Institute for Genomic Biology (IGB) (2003)	New York State Center of Excellence in Wireless and Information Technology (CEWIT) (2003)	Clinical and Translational Science Institute (CTSI) (2008)
National Center for Hypersonic Combined Cycle Propulsion (2009)	National Institute of Child Health and Human Development Center for Research in Reproduction and Infertility (2009)	Institute of Chemical Biology and Drug Discovery (2004)	Department of Environmental and Global Health (EGH) (2009)

UVa Applied Research Institute (ARI) (2011)	NSF Industry/University Cooperative Research Center for Innovative Instrumentation Technology (CiiT) (2013)	Louis and Beatrice Laufer Center for Physical and Quantitative Biology (2008)	Engineering Innovation Institute (2011)
Data Science Institute (2013)	Illinois Applied Research Institute (2013)	Simons Center for Geometry and Physics (2009)	Institute for Cell Engineering and Regenerative Medicine (ICERM) (2012)
Center for Automata Processing (2014)	NASA Astrobiology Institute: Institute for Universal Biology (2013)	Institute for Advanced Computational Science (2012)	

While the sampled SOIs in this thesis covered a range of organizational units and STEM fields and disciplines, they were not necessarily comprehensive or representative. The Commonwealth Center for Advanced Manufacturing in the state of Virginia provides an example. It includes UVa within a multi-institution and -industry research partnership that supports state economic development and also competition for federal R&D funding. In relation to UVa, the center is located off-grounds and just south of Richmond and could have been included in the study but has not been. At UIUC, the legendary Beckman Institute for Advanced Science and Technology was developed in the mid-to-late 1980s and fell beyond the scope of SOIs developed between 2000 and 2014. These types of omissions may limit some the generalizability of research findings to all SOIs within and across the four campuses yet nonetheless point toward areas for future study.

Research participants

The sampling of individual research participants for interviews was purposive and criterion-based (Merriam, 2009). Gumport and Jennings (2005) suggest that for case studies of academic structure researchers and analysts should consider interviewing people throughout the various organizational levels: institutional leaders, deans and directors of colleges and schools, department chairs, and faculty. To include their perspectives, Gumport and Jennings note, can tell us about the dynamics of change at particular campuses. Such an approach, as well, could lead to different layers of analysis that situate individual perspectives in relation to political interests and goals (Gumport, 1993). The criterion for sampling of participants in this analysis was an individual's appointment that located him or her within the organizational hierarchy of the institution and SOI.

There were three sets of individuals for recruitment in the study by appointment type. The first set of potential participants included faculty members who founded, led, and/or currently held an administrative position with an SOI (e.g., SOI administrators). A second set of potential participants included faculty members who pursued research with an SOI (e.g., affiliate faculty). Both sets of potential participants were considered knowledgeable about organizational change at the "ground level," where the impetus for adaptation but also the work of those within the research core was likely to occur. To broaden understandings of organizational change, a third set of potential participants was identified. This set included campus administrators at the system, institution, college and school, and/or department level who had direct involvement in or knowledge of SOIs (e.g., campus leaders).

The formation and development of SOIs happens over time, suggesting needs to sample participants from each of the three sets with current, former, and emeriti appointments. For instance, some faculty could move into different positions on campus (e.g., from departments to college or campus administration and vice-versa) or retire. “Recall error” could be an issue with those asked to share historical perspectives but who misremember or have forgotten some details of key events (Yin, 2014). But a balanced sample of those actively involved in day-to-day operations and those formerly involved may temper such a methodological concern.

Publicly available websites for each institution and SOI were used to identify key SOI administrators, affiliate faculty, and campus leaders. To select those individuals who were *most* influential in the formation and development of SOIs, and to reach saturation of individual respondents, *network sampling* was utilized by which participants were asked to recommend additional participants based on centrality to the case (Roulston, 2010). In total 75 individuals across the four institutions consented to participate in the research. Table 3 shows 77 respondents: I counted two of the 75 individuals twice because each of them had affiliations with more than one institution in the study.

TABLE 3. Research participants, by institution and general position

	UVa	UIUC	SBU	UF	**Total**
SOI Administrators	12	13	10	9	44
Affiliate Faculty	3	3	5	6	17
Campus Leaders	3	4	5	4	16
Total	**18**	**20**	**20**	**19**	**77**

As Table 3 suggests, the sample of individual participants is mostly comprised of SOI administrators (57%), followed by affiliate faculty members (22%) and campus leaders (21%) respectively. This thesis may reflect the perspectives of SOI administrators, then, more than those of research participants from the other organizational levels. Yet other considerations may also shape that which participants share about their experiences. To elaborate, it may help to describe broadly the within-group proportion of participants by academic rank and gender.

Table 4, below, shows that the sample of 75 individuals features a predominantly senior group of male faculty members. More than half of all participants (61%) were full professors or held endowed chairs/distinguished professorships, and about 19% was female. Among SOI administrators (n=43), faculty members at these senior ranks together constituted a striking 67.4%. Affiliate faculty (n=17), also, were mostly senior in rank, and associate professors represented just less than a quarter (24%) of this group. For campus leaders (n=15), there was a high proportion of emeritae who were included to this extent as their perspectives might help to fill in gaps about institutional histories. As data on gender suggest, almost half of the campus leaders in this thesis were women (47%), though about 12% of SOI administrators and 12% of affiliate faculty were women. The gender skew among SOI administrators and affiliate faculty, relative to the disciplines and fields of emphasis in this thesis, may not be surprising (e.g., Slaughter et al., 2002; Volk et al., 2001). It points toward an important area for future research, on which I elaborate in Chapter 7.

TABLE 4. Percent of research participants, by academic rank and gender

	SOI Administrators (n=43)	Affiliate Faculty (n=17)	Campus Leaders (n=15)	Total (n=75)
Academic Rank				
None	11.6	--	6.7	8.0
Assistant Professor	0	11.8	0	2.7
Associate Professor	16.3	23.5	0	14.7
Full Professor	39.5	29.4	20.0	33.3
Endowed Chair/ Distinguished Professor	27.9	29.4	26.7	28.0
Professor Emeritus/a	4.7	5.9	46.7	13.3
Gender				
Female	11.6	11.8	46.7	18.7

Note: "None," a category under Academic Rank, includes the percentage of SOI administrators and campus leaders who may hold PhDs but who do not have joint academic appointments.

Any categorization of research participants may have some limitations. "Campus leaders," in their appointments, often had research affiliations with SOIs, and many SOI administrators pursued research with their own and also other units at their institutions. Some affiliate faculty had become SOI administrators as part of the cycle of leadership changes in campus units. Yet such a broad typology of participants indicates, even if generally, the degree of closeness and involvement with the SOIs in this study.

Self-selection of participants may skew some of the study results. To clarify potential biases, let us consider the reasons why individuals have either consented or declined to participate. For some respondents, participation in the research meant an opportunity to promote a particular SOI and/or emerging discipline. As one UIUC respondent wrote in an e-mail: "Your project sounds interesting. Will you be publishing the results? This could be good publicity for [us and others] you might cover." Other participants viewed their experiences with SOIs as part of the public record. Indeed, a respondent at UVa consented to have the interview recorded, explaining: “This is all public.” A third, clear reason for participation was a motivation to communicate to the public about science. Relatedly, others viewed science as an opportunity for societal impact by way of public service and outreach: as one respondent at UF said, “The reason that I chose to pursue an academic career versus going into industry was that the service mission was very important to me and…I could impact that much better and more effectively from an academic role than an industrial role…because it’s quite literally part of my job description.” Those who did *not* participate included those who never replied to e-mail and follow-up contact, and those who declined by e-mail. Of the latter, examples were a faculty member at UVa who wrote by e-mail, “I will be out of town next week. Best wishes on your studies.” Another potential participant at UIUC wrote, “Thank you for your message, but I must decline. My schedule is quite full already.”

Data collection and analysis

For data collection for this thesis, I conducted site-visits, interviews, document/archival research, and, to some degree, semi-structured observations. I visited each of the four universities for a five-day period in the fall of 2014. During that time on the campuses, I held individual interviews with research participants and spent 22 hours (about five-and-half hours per institution) in campus archives with documentary materials. Additionally, on a few occasions, I had the opportunity for semi-structured observations during tours of facilities and laboratories. In this section, I outline the steps involved in reaching out to potential participants, conducting and coding the interviews, sampling documents and archival data, and generating field notes for the analysis.

To invite prospective participants to interview, I sent an e-mail in summer and fall 2014 to each individual one month in advance of a site-visit to his or her campus. The e-mail contained brief text about the study and an invitation to participate, along with an attached, formal letter that detailed the research and aim/scope of the interview (Appendix A).[29] If prospective participants did not respond to the initial e-mail and letter, they received a follow-up message within two weeks of the site-visit to campus.

During site-visits to each sampled SOI at the four universities, I interviewed participants in individual meetings in his or her office or laboratory. For participants who were unavailable for in-person meetings, they had phone interviews. I conducted about 25% of the interviews by phone, and I e-mailed questions to two respondents, who were unavailable for phone interviews, and classified their written responses as interview transcripts. Of the 73 individual participants who had in-person or phone interviews, the average length of the interviews was 45 minutes.

All but one participant consented to have the interviews recorded and transcribed verbatim. For the interview with this particular respondent, I took field notes. The interview questions (Appendix B) followed Rubin and Rubin's (1995) guide of having main questions, intended prompts or probes for clarification, and follow-up questions for extended discussion of topics. In this way, the interviews were semi-structured to cover areas of importance to the study but also to allow leeway to take interviews in directions that respondents wanted. No participants excised data or withdrew from the study.

[29] See Hermanowicz (1998, 2009), Johnson (2011), and Rubin and Rubin (1995) for methodological commentary on—and examples of—cover letters to academic scientists.

Documentary materials and archival records supplemented the interviews as part of data collection for the analysis. The research included 22 hours of archival work—about five-and-half hours per institution. During this time, I focused on presidential correspondence files in which I studied institutional leaders' written communication with AAU presidents and other leaders of member institutions, internal memoranda about the AAU, and, more generally, historical developments in the research mission and strategic planning of that particular university. Additionally, individual research participants often provided documents, ranging from glossy brochures to self-studies and unit-level strategic plans. And newspaper articles, which contextualized developments at the sampled institutions and/or at the sampled SOIs, were also included in data collection.

The five-day site-visits per campus did allow for some semi-structured observations of the SOIs and suggested the use of ethnographic methods (e.g., Schensul, Schensul, & Lecompte, 1995). While I did not attend any formal department meetings or events, I made several direct observations of laboratories and buildings/facilities on the campuses. Some research participants gave, at the conclusion of the formal interview, tours of their laboratories and/or units. I structured these observations around guiding questions of organizational structure and resources, legitimation of SOIs on campuses, politics as manifested through allocation of space and facilities, and interpersonal dynamics and culture. To generate data from these observations, I took field notes in a journal between interview appointments and at the end of each day of the site-visits.

For data management, I organized electronically by institution the interview transcripts and e-mail responses, documentary materials, and field notes. Some documentary materials were in hardcopy form only, and I collated these in piles by institution as well. I then reviewed each individual item and institutional set of materials, identifying segments of text most pertinent to the research questions of this study and coding them manually in Microsoft Word and, for some items, in hardcopy by hand. My analytical strategy included the use of both *a priori* codes derived from the guiding theoretical framework and emergent codes grounded in the data (Appendix C). Through *a priori* and emergent coding, I was able to analyze as much relevant data as possible.

To elaborate the coding process for this study's analysis, I followed protocols from methodological literature (see Corbin & Strauss, 2008; Stake, 1995): First, I used *open coding* to identify broad themes (e.g., federal R&D funding). Second, I used *axial coding* to refine broad themes into categories (e.g., federal R&D funding—areas of long-term commitment, federal R&D funding—areas of potential growth, federal R&D funding—responsiveness to federal priorities, federal R&D funding—strategies to influence outlays, etc.). Finally, I used *selective coding* to develop narrative threads around categories of data (e.g., co-opting federal R&D funding streams).

The multiple embedded case-study design provided opportunities for within- and cross-case analyses. Themes from data pertaining to one case—the continua of SOIs within an institution—were considered and then compared to themes from the other cases, the SOIs, at the other institutions. To this end I relied on constant-comparative and pattern-matching techniques (Miles & Huberman, 1994). For each case and institution, I compared themes from one interview to references to similar or comparable themes in other interviews, documents/archival materials, and field notes. For instance, when one participant repeatedly mentioned resource scarcity in motivating organizational change and adaptation, I searched for references to resource scarcity in other interview, site-visit, and documentary data from the same institution. As part of the cross-case analysis, I examined interview and supporting data from the other research participants and sites to determine whether similar or different themes were present.

Trustworthiness, quality, and rigor

As a multiple embedded case analysis, drawing on qualitative data and methods, several measures were taken to meet standards of trustworthiness, quality, and rigor. According to methodological literature (e.g., Merriam, 2009), trustworthiness refers to internal and external validity. In this section I enumerate the ways in which the research design and procedures of this thesis aimed to address issues of validity. By way of establishing an "audit trail" of decision points throughout the research process (Lincoln & Guba, 1985), reliability (e.g., repeatability) of this study's findings may be approached.

For internal validity, I utilized three forms of triangulation. First, *multiple data sources* (interviews, documents/archival materials, and observations) were included in the collection and analytical phases of the research. Interviews provided the majority of data for this thesis, but carried the potential for a degree of recall error (Yin, 2014). Documents/archival materials as well as field notes from site-visits thus offered a way to triangulate interview responses, filling in possible gaps in perspectives. At the same time, interviews deepened understandings of the networks and social relations that were likely to underpin written, documentary materials (see, for instance, Prior, 2003). Together, these multiple data sources suggested that the nature and emergence of SOIs were indeed studied and analyzed and that resulting empirical claims were verifiable.

As the second form of triangulation, *multiple observations* of some of types of data at different time points were utilized. The use of archival materials—in addition to recent brochures, strategic plans, and newspaper articles—contextualized how a campus and its units had changed over time. For instance, presidential perspectives about the AAU in official correspondence or internal memoranda from one time period (e.g., the early 2000s) could be different from presidential perspectives in correspondence or internal memoranda from preceding years (e.g., the 1990s). Tracing such accounts in comparable documentary materials over time offered a way to strengthen the empirical evidence for this thesis. Additionally, the inclusion of interview respondents with emeriti appointments added a longitudinal dimension to understandings of SOIs and strategic change on campuses. Thus present-day, "on the ground" accounts were considered along with recent accounts of historical developments, contributing a level of saturation to understandings of the nature of variation and emergence of SOIs.

A third form of triangulation came from bringing multiple theories to bear on the research. This thesis draws on institutional theory, resource dependence theory, and academic capitalism. The theories are not necessarily rival or competing, but together cover several conceptual *angles* of explanation for study results. In this way the thesis was positioned for "conceptual triangulation" (see Yin, 2014).

The sampling strategy for this thesis was intended, in part, to address concerns of external validity: the extent to which the research design allowed for generalizability/transferability of results from these cases to others. The institutions selected for study were largely representative of their respective quadrants of innovation. Their empirical themes might reflect, to a considerable degree, those likely found among the other institutions in their groups. In this analysis the SOIs—the cases—did not necessarily represent all emerging organizational forms within and across the four institutions, limiting some the applicability of results elsewhere. But their particular details as rendered through case analysis aimed to increase the likelihood of readers finding aspects of the universal (Merriam, 2009).

An audit trail (Lincoln & Guba, 1985), as outlined in this chapter, documented the decisions made throughout and analytical procedures of the research. Such a record, especially of the coding scheme, offered some reliability to this thesis. Another researcher might not outright replicate the qualitative study and findings reported here. Yet disclosure of the processes and procedures of this study was intended to offer transparency as part of the research design's evaluation.

Summary

This thesis utilizes a multiple embedded case-study design, where the SOIs (e.g., the case) within an institution are compared to SOIs (e.g., the cases) within other institutions. UVa, UIUC, SBU, and UF were sampled from its respective quadrant of innovation, based on indicators of institutionalization and resource position. From each institution SOIs were sampled that, in short, provided an adequate set of the most recent emerging organizational forms largely in the biomedical arena of federally funded research. Site-visits/observations, interviews, and document/archival analysis provided the level—and saturation—of data needed for trustworthiness, quality, rigor, and empirical robustness. In the next chapter, the within-case findings are presented that summarize the cases, the continua of sampled SOIs, at UVa, UIUC, SBU, and UF.

CHAPTER 5

WITHIN-CASE FINDINGS

The continua of SOIs—the cases—at each institution in this study are a purposeful sample of the most recent emerging organizational forms to date on their campuses. For inclusion in this analysis, and to ensure an adequate, timely sample, the centers, institutes, schools, and departments had to have formed between 2000 and 2014. They were in their names called centers, institutes, schools, and departments, served the research mission of their institutions, and had identifiable goals, personnel, and budgetary capacity. Additionally, they had websites to promote themselves and their particular strands of science (e.g. nanotechnology, pharmaceuticals, biomedicine, computing, etc.). Application of sampling criteria within and across the four institutions in this study yielded 35 SOIs. In this chapter, summaries pertaining to SOIs (e.g., the case) at each institution are highlighted as part of the within-case analysis.

Recall that the institutional sampling, based on institutionalization and resource position within a field, presents an opportunity to situate SOIs in context. Within this introductory section, let us consider a brief overview of the SOIs and institutions. UVa, in the first quadrant of innovation of "high institutionalization/resource strengthened," features nine sampled SOIs: all centers and institutes. While it has notably pulled its largest share of federal R&D funding from the NIH for medical-related research, UVa's SOIs suggest developments in Engineering to broaden some funding streams and open industry partnerships. The SOIs do not stray too far from UVa's core funders or historic normative environment on campus (with the exception of defense-funded SOIs), and they appear to form a network of units for cost-sensitive approaches to nimbleness. UIUC, in the second quadrant of innovation of "high institutionalization/resource threatened," has nine sampled SOIs: a mix of schools (two), an academic department (one), and centers and institutes (six). Its SOIs concentrate in areas of scientific legacy around NSF money, in biology and the life sciences, but shift some in later years toward the intersection of engineering and medicine. They suggest aims of generating money and, while not as densely connected as UVa's SOIs, championing the longstanding reputation of UIUC in scientific advancement.

SBU, in the third quadrant of innovation of "low institutionalization/resource threatened," is the youngest of the sample in year of AAU induction (2001) and founding date (1957) and has nine sampled SOIs. Its centers and institutes (eight) and an academic department (one), which orient toward its top three funders (listed in order) of the NIH, NSF, and DOE, suggest movements in the physical, biological, and medical sciences and in engineering. The SOIs at SBU suggest capital investments to build research infrastructure and capacity, but also efforts, from a resource threatened position, to reach outside of themselves to donors and external partners for money to innovate. UF, in the fourth quadrant of innovation of "low institutionalization/resource strengthened," has eight sampled SOIs of centers and institutes (six) and departments (two) that largely seek to continue the institution's success in NIH funding. Vast and complex organizationally, UF's centers and institutes aspire to coordinate research collaborations across campus and entwine the main academic core and medical enterprise. Despite a strong resource base, UF could find it difficult even with selective state investments to outspend its competitors to rise in prominence.

While institutionalization and resource position can account for SOIs within and across the four institutions, they are not the only motivators of organizational change. It may help to clarify other influences that could shape—and differentiate—structural adaptations on these campuses. Of these, campus size/scale, endowment resources, and state funding environments could be especially prominent.

Public research universities are known for their size/scale. Elite private institutions win the most federal R&D funding, but on the whole, because of limited organizational capacity, tend to produce a lower volume of research, teaching, and service than public institutions (Brint, 2005, 2007).[30] FTE undergraduate and graduate enrollment varies somewhat across the institutions in this study. In 2013, based on the most recent, publicly available IPEDS data, UVa had 22,275 students, UIUC had 40,030 students, SBU had 22,094 students, and UF had 46,184 students.

The numbers suggest the scope of research initiatives and academic offerings on each campus. On the moderate end of public institution enrollments, UVa and SBU boast relatively small programs in concentrated areas of the liberal arts, pre-professional programs, and STEM. As textbook "multiversities" (Kerr, 1994), UIUC and UF represent the high end of public institution enrollments. They are massive. We may find

[30] Recall from Chapter 4 that private AAUs were on average both older in their AAU membership and richer in scale-adjusted federal R&D funding than the public AAUs. Mathematically, the relative wealth of private AAUs in federal R&D funding could be attributed to high numerators (e.g., raw grant dollars) and low denominators (e.g., small FTE enrollments). Yet public AAUs had about 1 percent more growth than their private counterparts in federal R&D funding over time, suggesting capacity for innovation and adaptation to compete.

at each experts in nearly all fields and disciplines, spread across acres and acres of land-grant campuses. Much of UIUC's growth has been in STEM and in engineering, the life sciences, and agriculture, though recent directions suggest aims of integrating these strengths with medical sciences. For SBU, its small size makes the institution's accomplishments in research and graduate education rather distinctive (Geiger, 2010). UF moves in all fields and disciplines at once, but positions heavily around the engineering and medical enterprises.

It may help to clarify the FTE graduate enrollment at each of the institutions, for graduate education is often associated with support for the academic research enterprise (e.g., Gumport, 2011). As 2013 IPEDS data suggest, UVa had 6,382 graduate students, UIUC had 13,417 graduate students, SBU had 5,430 graduate students, and UF had 10,878 graduate students. The size of graduate programs by institution suggest notable variation, but the ratio of graduate students to total FTE enrollment is somewhat comparable across the four institutions, constituting 27% at UVa, 27% at UIUC, 23% at SBU, and 23% at UF. Thus, the four institutions emphasize graduate education to similar extents relative to their overall size.

To elaborate an institutional profile for each sampled university, size of endowment resources further distinguishes the campus financial capacity for structural adaptation. Most colleges and universities in the U.S. draw no more than 5 percent each year from their endowments. Some may direct a portion of money to fund strategic change. Institutional and foundation money can cover front-end investments in SOIs, especially in matching external gifts and grants and subsidizing the costs of capital projects and new faculty lines. Endowment wealth may account for variation in strategic response by institution, because it provides access to resources whose deployment can reposition organizations in their environments (Hearn, 1988; Morphew, 2009; Oliver, 1991).

Let us consider the scale-adjusted endowments of UVa, UIUC, SBU, and UF. In 2013 nominal dollars based on IPEDS data, UVa had the largest endowment of sampled institutions with $229,265 per FTE enrollment. At the campus-level, UIUC had an endowment of $24,413 per FTE enrollment. SBU had a relatively small endowment of $7,001 per FTE enrollment, and UF had an endowment of $29,499 per FTE enrollment. In some ways, endowment levels lend support to the sampling of universities by institutionalization and resource position. UVa comes from a long-standing elite position with considerable resources. UIUC has a history of prominent status/standing, though falls somewhat below AAU entrants younger than itself (e.g., UF) in resources. Recall that UIUC flat-lined over time in federal R&D funding, a pattern indicating a resource threatened position. SBU has been a recently designated AAU member in 2001 but seems to continue to innovate from a tight resource-base, and UF continues to reflect ascendancy in prominence by way of elite AAU status certified in 1985 and its endowment wealth.

UVa, UIUC, SBU, and UF differ in their institutional wealth, yet share in common the ongoing decline of direct state support. It may help to specify the state resource climate in which each institution is situated. In each of five years from 1990 to 2010, UVa's state funding of appropriations, grants, and contracts dropped on average by

22%, UIUC's by 16%, SBU's by 8%, and UF's by 18%.[31] Such disinvestment from states, though more severe in Florida, Illinois, and Virginia than in New York, could trigger proportional strategic initiatives for other sources of money. Academic capitalism (Slaughter & Rhoades, 2004) suggests the repurposing of state funds for allocation to R&D for economic development. But the overall downward trend reported here offers some evidence of long-term retrenchment in state funding to public higher education that targeted investments will not overcome. The pattern also indicates comparable state funding environments in which the SOIs in this study have emerged.

Descriptive, numeric data highlight core characteristics and financial circumstances of the sampled institutions. This chapter reports empirical results of the within-case analysis, aiming to assay the SOIs as located within their campus contexts. It consists of five sections: one per institution and a concluding summary. In each section, an overview is provided of each institution's longitudinal federal R&D funding profile, disaggregated by mission agency. Then the sampled SOIs are discussed and considered in terms of how closely they cohere and interact—aiming for *fluidity* and *continuity* of research, money, and people—within a matrix. Additionally, key themes particular to the home campus and its SOIs are presented to codify the contextual influences on change and adaptation. Though tempting to foreground the obvious (e.g., the use of SOIs to

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[31] Percentages are derived from IPEDS data from 1990, 1995, 2000, 2005, and 2010 and represent the median percentage change for each institution over the 20-year time period. To clarify the decline of direct state support to each institution, it may help to consider the dollar value at stake. In 2010 constant dollars, UVa went from $14,069 per FTE enrollment in 1990 to $6,826 per FTE enrollment in 2010, UIUC from $18,069 per FTE enrollment in 1990 to $8,336 per FTE enrollment in 2010, BU from $24,848 per FTE enrollment in 1990 to $20,231 per FTE enrollment in 2010, and UF from $26,582 to $13,702 per FTE enrollment.

broaden revenues), the emphasis here focuses on tensions and paradoxes of institutionalization and resource position within the quadrants of innovation. In this way, we may understand the points and counterpoints of structural adaptation as rooted in institutional recourses to change. The sections, which integrate historical snapshots and contemporary developments, offer background for a cross-case comparison in Chapter 6.

Innovating in Quadrant I: University of Virginia

Four themes underscore the SOIs at UVa in Quadrant I of high institutionalization/resource strengthened. First, SOIs aimed to leverage strong resource-bases to move beyond NIH and NSF niches and money, but institutionalization kept them from straying too far from core research areas and funders. Second, for a resource-strong institution, SOIs were largely a network of units for cost-sensitive approaches to fluidity and continuity of research, money, and people. Third, prominent decline of state funding motivated adaptation to diversify revenues, though expanding federal money did not necessarily *replace* state dollars. Finally, community-wide strategic planning countered recent board intervention in campus governance, yet proposed innovations had to fit UVa's heritage and standards of excellence.

Federal R&D Profile: "*Enlarge the research pie.*" As Figure 8 shows, UVa derives its largest share of federal R&D funding from NIH. In median percent of funding from each mission agency over time, it receives 66% from NIH, 13% from NSF, 7% from DOD, and 4% each from DOE and NASA. Considerably less funding over the years comes from a combination of various agencies (3%), DOT (1%), EPA (<1%), USDA (<1%).[32] The reliance on two primary agencies, the NIH and NSF, can be problematic when the government shifts budgets that tighten outlays and heighten the competition for money.

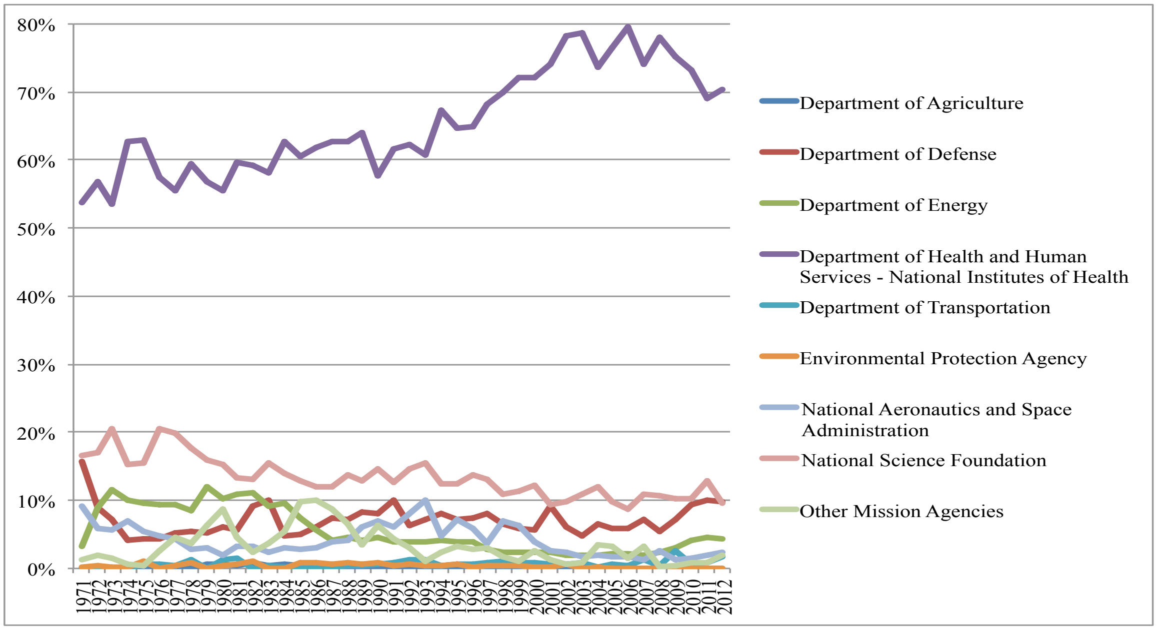

Figure 8. Percent of federal R&D obligations to University of Virginia, by mission agency, 1971-2012. *Source:* National Science Foundation, *Survey of Federal Research and Development Obligations.*

The SOIs at UVa largely position around different federal R&D areas and agencies in attempts to broaden funding streams. As one SOI administrator observed:

> [We're] trying to enlarge the research pie. …So as you go to the National Science Foundation and the National Institutes of Health,

[32] The various agencies, aggregated for reporting purposes, consist of the Department of Commerce, the Department of Education, Department of Health and Human Services (Centers for Disease Control, Food and Drug Administration, Health Resources and Services Administration, Office of the Assistant Secretary for Health, Other), Department of Housing and Urban Development, Department of Labor, Department of the Interior, Nuclear Regulatory Commission, Office of Justice Programs, and the Social Security Administration.

> you find more people trying to divvy up a pie that's getting smaller. So the competition is brutal. Success rates at NSF are under 10% now, so, you know, it's hard to think, "Should I spend my time doing this?" So we have gone after a different piece of the research community, and that's the classified area. So we have clients at the National Ground Intelligence Center and at the Defense Intelligence Agency that we work with, and so we work on the "black side" of things.

Such a perspective suggests efforts to generate revenues from research contracts, though in ways that prompt ethical quandaries (e.g., pursuing classified research).[33] Yet UVa's share of grant funding from DOD has shown an upward trend since 2008. The emphasis on centers and institutes, as compared to departments and schools, suggests adaptive moves that, as another SOI administrator said, serve as a "conduit" and "translator" between mission agencies and UVa faculty members.

The role of SOI administrators is important. By bringing new funding opportunities to faculty attention, and helping faculty work with mission agencies on federal funding priorities, leaders of centers and institutes can help affiliate members gain national visibility and recognition. As a faculty member explained, securing external grants by way of SOIs could help to "feed" themselves and their work. Campus leaders are, of course, active in the process of encouraging the development and external positioning of SOIs. A campus leader said, "Our departments are pretty small. It will be very hard for any of our departments to get recognized as national leaders in an area. But if we combine them together because together they can solve the problem, then all of a sudden we can magnify the effect." Efforts to "combine" departments—that is, to foster

[33] Historically, faculty members at UVa have been allowed to pursue classified research. In recent years, the increasing emphasis on this funding stream seems to overlap revisions to UVa's institutional policy: http://uvapolicy.virginia.edu/policy/RES-003.

cross-collaboration among faculty members—typically entailed seed-funding opportunities.

Analogous to most research universities in the U.S., UVa innovates to broaden its federal R&D funding streams. Unlike most other institutions, however, UVa could leverage its status/standing and resources to pursue whichever directions it wants. It could also buffer itself from change. But in relation to federal R&D funding it does neither. The institution changes though in ways that seem largely to affirm its relevance as cutting-edge to longstanding funders.

The SOIs: "This center really fits in a network of support." As this study's data suggest, UVa has notable growth in SOIs for an institution already strong in status/standing and federal R&D funding.[34] Recall that, summarized briefly above, its nine sampled SOIs are centers and institutes mostly positioned around mission agencies. It may help to summarize them and indicate the extent to which the SOIs fit together within a matrix.

The NSF Industry/University Cooperative Research Center (I/UCRC) for Lasers and Plasmas was founded in 2002 to contribute to developments in advanced manufacturing. Within the parameters of the NSF, the I/UCRC has multiple institutions involved in research and charges fees to industry members to participate. The

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[34] When the AAU began to re-evaluate its members in the late 1990s and early 2000s, UVa President John T. Casteen III had an integral role in the executive committee. Indeed, on July 24, 2003, he wrote a letter as AAU's acting chairman to Syracuse University's Chancellor Kenneth A. Shaw to say that Syracuse, which was under review, was not going to be dismissed from the AAU at that time. Member presidents rotate AAU positions, but President Casteen's involvement could be viewed as indicative of UVa's longstanding prominence among the research university elite. See, for instance: John T. Casteen III to Kenneth A. Shaw, July 24, 2003, Papers of the President of the University of Virginia, Office Administrative Files, Box 5, Accession #RG-2/1/2.061, Special Collections, University of Virginia Library, Charlottesville, Va.

membership fees are intended to sustain the center, though continuity in funding can still be hard to secure.[35] Its laboratory and facilities are off "grounds" (UVa's word for "campus").

While the I/UCRC has the clearest, most direct mission-agency link, the Institute for Nanoscale and Quantum Scientific and Technological Advanced Research (nanoSTAR) was formed in 2004 in response to national interest in nanotechnology. It represents a *standard* institute, with a bricks-and-mortar office and multiple core research facilities. Since its inception, the institute has received money from the institution and the School of Engineering and Applied Science, and it works to pull in grant funding and also seed-fund other centers and institutes. nanoSTAR's focus has been on biomedicine, electronics, and energy and the environment, with its seed-funded centers and institutes emphasizing other emerging areas of research, including automata computing for "big data" and nano-bio research on micro and nano fluidics and tissue engineering. Through nanoSTAR's "Partnership and Innovation Program," private industry partners may purchase membership for a minimum of $2,000 that provides access to faculty members, collaborative research, and students; a "principal membership" of $20,000 buys a seat on nanoSTAR's industrial advisory board as well as a preferred intellectual property position.

The UVa Center for Wireless Health began in 2009 in the School of Engineering and Applied Science. It suggests a *virtual* center formed around already-existing infrastructure and research expertise of senior faculty members. Though it does not receive institutional or departmental funds, a hallmark of virtual forms (Bozeman &

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[35] The business model of charging membership fees resembles MIT's approach, which the institution has practiced since the 1920s or so.

Boardman, 2013), it positions around federal R&D funding for behavioral research. The center's niche focuses on leveraging technology to monitor and coordinate health information for the elderly. Based on $2 million in funding from NASA ($1 million) and the Air Force ($1 million), the National Center for Hypersonic Combined Cycle Propulsion was founded in 2009. It seeks to design and test engines that could send payload to space and move fast enough to intercept missiles for national defense efforts. Budget cuts for NASA prompted the agency to rescind its $1 million grant, which limited some of the center's work. Located within the School of Engineering and Applied Science, it has a dedicated facility, reminiscent of an army bunker, on grounds where faculty members run and model simulations and burn fuel. The dean allocates some funding to cover the cost of graduate students who pursue research with the center. It represents a blending of *standard* and *adaptive* forms: it has bureaucratic characteristics but can repurpose around funding opportunities.

The UVa Applied Research Institute (ARI) was founded in 2011 to partner with the defense intelligence community and private industry. It started in the School of Engineering and Applied Science but in 2013 moved under the supervision of the Provost whose office provided some funding for the Institute. ARI is *virtual*, but has facilities in the research park for industry partners and off grounds for classified projects. Recently the Data Science Institute (formed in 2013) and the Center for Automata Processing (formed in 2014) each correspond to government and industry interest in computers and big data. The Data Science Institute, reporting to the Provost, was launched with a $10 million endowed gift, and the Center for Automata Processing in the School of Engineering and Applied Science started based on money and investment in technology from nanoSTAR and, notably, the private company Micron. Both are *virtual* entities, but through external money can bring new technologies and research collaborations to existing facilities.

Two of the nine SOIs do not necessarily fit within the federal R&D funding purview. The Center for Global Health, founded in 2001 in the medical school, has an explicit teaching and service mission. By way of its bricks-and-mortar location on grounds, it sponsors trips to developing countries to provide on-the-ground support to battle and limit the international spread of infectious diseases. The Center does compete for external grants from major philanthropic foundations, such as the Gates Foundation, and because it channels and allocates money and forms cross-campus partnerships with faculty by way of the medical school, it warrants attention in this thesis. SHANTI, which began in 2008, was developed from an institutional strategic planning recommendation. The aim was to provide a "digital ecology" by which the center offered in-house e-services that precluded needs for a third-party provider. It, too, has the capacity to compete for grants and institutional funding, meriting consideration as one example of a center intended to respond to campus rather than federal funding needs per se.

Of theoretical interest, the sampled SOIs at UVa favor Engineering and constitute interconnected organizational units. As one SOI administrator said,

> So if we had just formed this center as a group of faculty on our own, and then started going and trying to basically knock on doors [for money], it would have been harder. We also have an Applied Research Institute here at the university that has some connections with funding agencies that they try to leverage, to help faculty all across the university, so that's another organization out there. So this center really fits in a *network of support*, you might call it. (Emphasis added)

By and large the SOIs on campus formed a network through which research, money, and people were exchanged. According to another SOI administrator, some centers and institutes "get some seed money to throw around to get people to start talking to each other [and are] looking for cross-grounds groups to actually nurture…just to get roots together."

For a resource-strong institution, UVa's network of SOIs suggests cost-sensitive approaches to change and adaptation. The fluidity of boundaries among institutes and centers allows for exchanges of research, money, people that help the participating units sustain themselves (e.g., achieve continuity in their work, finances, and personnel). Interestingly, UVa has a number of core research facilities but features mostly *virtual* centers and institutes. Clearly virtual organizational forms require minimal institutional investment, as they have relatively low overhead and no new capital-project demands, and have the most permeable unit boundaries. While UVa has robust resources and high growth in federal R&D funding, it pursues innovation by way of SOIs on the margins of enduring institutional and financial commitments.

The Quest to Replace State Money: "We're so under-resourced." The ongoing decline of state funding to UVa, dropping on average by 22% in each of five years from 1990 to 2010, further justified organizational change for resources. Indeed, part of this pattern of public disinvestment from UVa is part of the institution's agreement to gain autonomy by accepting less broad based state appropriations (Pusser, 2008). Despite the institution's latitude to become increasingly entrepreneurial, coupled with historically strong endowment wealth, some respondents nonetheless viewed UVa as facing strict financial constraints. An SOI administrator explained that UVA "is like a community college sometimes. I mean, we're just so under-resourced, despite having…an endowment that is relatively large." While not all research participants viewed UVa as a "community college," they often noted the increasing pressure to diversify revenues. The pressure was most salient among campus leaders, who actively sought donor support to build-up the academic infrastructure. From 1990 to 2010, an emeritus campus official noted, 134 buildings were constructed, and by 2014 nearly all were named and endowed. Initiatives to broaden revenues by way of federal R&D funding, though, may not necessarily meet objectives. A current campus leader observed:

> If you go out for federal research funding…for every dollar of federal money you get for a research grant, you'll spend probably a $1.17 to accomplish the purpose of that grant. So, if you are losing operational money from the state, getting that grant hasn't really helped you support that whole launch. I think it's a mistake to see federal research money as a way of substituting for the state money.

Such a perspective suggests that the research enterprise loses money and may not necessarily replace what states no longer allocate. Institutes and centers, as virtual organizational forms, preclude capital construction and may thus help to improve adaptability at relatively low cost.

Overall perceptions of financial constraint at UVa conflict with some descriptive, numeric data. The discrepancy raises a question: why do perceptions "on the ground" and numeric data differ in their intimations about wealth? UVa is not poor. Yet it seems that the wealth it does have, independent of state appropriations, is committed. For instance, UVa focuses programmatically on residential undergraduate education more than many elite public and private counterparts. While the institution has a strong record of success in federal R&D funding, its revenue-stream for research does not necessarily increase overall financial capacity. In this way UVa is resource "constrained" because research dollars are sunk (e.g., are spent on costs related to research) before they are even received. It works on well-delineated margins to change and adapt, and the leveraging of private gifts and donations, from industry in the case of the Center for Automata Processing and philanthropists in the case of the Data Science Institute, is increasingly crucial.

The Cornerstone Plan for UVa's Future: "People are actually doing it?"

Prompted by its board, UVa initiated its current strategic plan, the Cornerstone Plan, in 2013. It comprises five pillars that aim to strengthen the academic and residential living and learning core. The second pillar is particularly striking: Strengthen the University's Capacity to Advance Knowledge and Serve the Commonwealth of Virginia, the Nation, and the World through Research, Scholarship, Creative Arts, and Innovation. To this end UVa leadership envisions forming five pan-university institutes that will increase the number of SOIs by which to generate national visibility and broaden the reach of outcomes from its research efforts. As the first of the five institutes, the Data Science Institute was launched in 2013 from a $10 million endowed gift.

Since 2000, UVa has had at least two other strategic plans: Vision 2020, initiated in 2001 and formalized in 2002, and the Committee on the Future of the University (COFU) in 2007. Mention of strategic planning can elicit some cynicism among SOI administrators and faculty members. An SOI administrator explained: "I've been a faculty member, what, 37 years now? Not all here, but 37 years, and I've probably seen 30 strategic plans. And none of them were ever used at all except the new—the latest one is a difference…and we're actually doing it. …People are actually doing it." Motivation comes in part from the abrupt firing and rehiring of UVa's President, Teresa Sullivan, in

2012, which, as reports suggest, unified a coalition of faculty members, administrative leaders, and alumni.[36] The community has rallied around strategic action to defend itself and prepare for the future.[37] An emphasis on cross-disciplinary participation in institutes and centers suggests one fruitful direction. To ensure the lucrative success of SOIs, as one emeritus campus leader said, universities have to "help with resources, and one kind of resource is space. The other kind of resource is dollars, and the third kind of resource is [faculty] positions." Though endowment strong, UVa continues to piece together external funding to innovate.

Strategic planning at UVa occurs within a strong normative context that shapes what can be implemented. From the influence of UVa's founder Thomas Jefferson, the institution has long championed the liberal arts. It has added, albeit slowly over time, professional schools in engineering, business, and in 2007—marking the first new school in 52 years—public policy and leadership. Because UVa has a long-standing history of being an elite institution, prestigious across programs, its organizational innovations have to meet high standards for approval and funding. An SOI administrator explained that for a major structural change to occur, a proposal should show that a new unit can be "excellent," fit the historic values and mission of UVa, demonstrate integrity to the faculty, and "excite" a donor. Though the legacy of Thomas Jefferson may seem a hindrance to forward progress, it gets at the core of change; after all, and analogous to other benefactors to U.S. public colleges and universities, he drew on his elite status and money to innovate in higher education when he founded an institution. In a contemporary context, campus leaders do indeed set visions for change and adaptation

[36] See Rice (2012) for an insightful summary and analysis of events.
[37] For an analysis of authority relations between UVa and the state, see Pusser (2008).

and, to an extent, steward resources to meet goals. But it seems that SOI administrators have taken on increasingly prominent roles in driving organizational change.

Innovating in Quadrant II: University of Illinois at Urbana-Champaign

Four themes underscore the SOIs at UIUC in Quadrant II of high institutionalization/resource threatened. First, for a historically NSF-funded campus, incremental shifts in the research core launched a fundamental repositioning around NIH money. Second, the SOIs, though not quite a network of fluidity, aimed to boost federal R&D resources to reaffirm continuity in the institution's longstanding reputation as scientific powerhouse. Third, the history of being an elite institution prompted change and adaptation to prevent loss of status/standing and increase resources. Finally, recent campus-level strategic planning suggested a departure from institutional roots to develop an engineering-medical enterprise distinct to American higher education.

Federal R&D Profile: "We need to get people who are fundable, of course." As Figure 9 suggests, UIUC has largely been an NSF-funded campus. In median percent of funding over time, UIUC receives 39% from NSF, 19% from NIH, 14% from DOD, 10% from DOE, and 8% from USDA. Additionally, it averages 3% from NASA, 2% from various other agencies, 1% from EPA, and less than 1% each from Department of Homeland Security and DOT.[38] Recall from Chapter 1 that NSF provides 12% of all

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[38] The various other mission agencies that have funded UIUC are Agency for International Development, Department of Commerce, Department of Education, Department of Health and Human Services (Centers for Disease Control, Centers for Medicare and Medicaid Services, Food and Drug Administration, Health Resources and Services Administration, Office of the Assistant Secretary for Health, and Other), Department of Housing and Urban Development, Department of Labor, Department of

federal R&D funding to universities and colleges, behind DOE (13%) and NIH (49%). To compete for the richest pot of money, many of UIUC's SOIs seek biomedical dollars. If successful the SOIs could help the institution realign its funding sources so that the NIH becomes the primary research-funding stream. UIUC has a medical school building, faculty members, and students on campus, though the main medical campus for Illinois resides in Chicago. While there are efforts underway to build its own distinctive engineering-based medical program, initiatives at UIUC suggest SOIs as important, intermediary steps to broaden research funding.

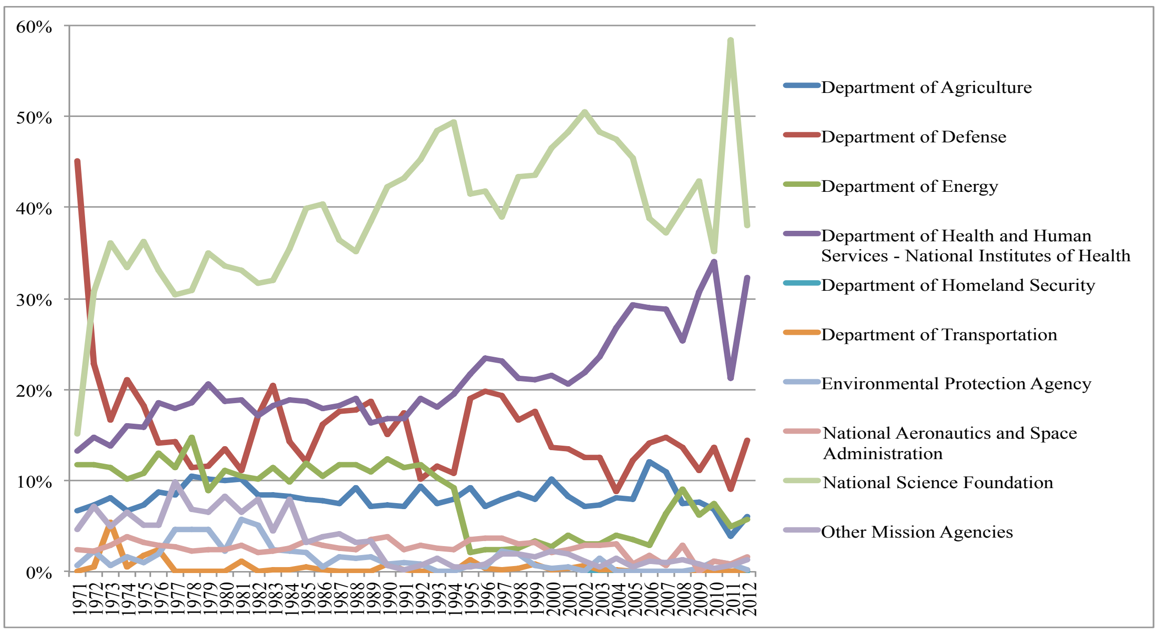

Figure 9. Percent of federal R&D obligations to University of Illinois at Urbana-Champaign, by mission agency, 1971-2012. *Source:* National Science Foundation, *Survey of Federal Research and Development Obligations.*

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the Interior, Nuclear Regulatory Commission, Other Federal Departments and Agencies, and Social Security Administration.

The SOIs at UIUC constitute a range of centers and institutes, schools, and departments in the life sciences and engineering. The diversity in type and focus suggest efforts to make departmental and collaborative boundaries, as one emeritus departmental leader said, “porous.” UIUC’s share of federal R&D indicates commitments to the NSF and its agricultural heritage by way of the USDA, but shows some increasing movement in 2012 in NIH biomedical money. Perhaps a subtle shift in funding patterns, the uptick in NIH funding heralds a prominent institutional strategic direction for UIUC. But aligning organizational structures and research agendas too closely with federal R&D funding from any mission agency can prompt vulnerabilities. This vulnerability is felt strongly among affiliate faculty and departmental leaders. One faculty member remarked, “Up until the bottleneck at NIH, I really had a lot of funding in that [scientific] area, and then NIH funding got very tight.” A departmental leader described how “funding goes up and down with the NIH budget. The NIH budget has been contracting for several years now, but our faculty have done really well competing for that funding. [We’ve] tried to hire into themes or areas that we thought would have strength, not so much looking at what we think NIH might be funding. We need to get people who are fundable, of course.”

The overall scope of structural adaptation at UIUC, analogous to UVa’s, focuses on established research areas of historical strength. UIUC’s SOIs, on the whole, do not necessarily move the institution into radically new arenas for competition. But unlike UVa, UIUC pursues an eventual, *substantive* repositioning: the creation of a medical enterprise with school and hospital in Urbana-Champaign. SOIs are not quite means to the medical enterprise ends, for they can help the institution affirm and extend external perceptions of eminence in STEM. They can also generate additional research opportunities, positioned around enduring funders, to deepen revenue streams. In the context of flat growth rates in federal R&D funding, money in general matters to UIUC.

The SOIs: "We have ideas, and we want to get people to give us money to pursue them." The nine SOIs at UIUC constitute six centers and institutes, two schools, and one academic department. They cover numerous scientific specialties and, especially through the work of SOI administrators, help to foster connections among faculty members across the institution's robust academic structure. Situated at interstices of STEM fields and disciplines, their aims by and large are scientific advancement and generating money. Because of UIUC's size and diffuse spread over the years of units all over campus, not all of the SOIs fit into a tightly defined matrix of fluidity and continuity of research, money, and people. But they can, each and in their aggregate, serve the purpose of promotion of reputation. They can remind external funders and peers of UIUC's extensive legacy of eminence in STEM.

In the late 1990s, analogous to national movements to reorganize and restructure the biological sciences (Jong, 2008; Trow, 1999), the School of Life Sciences in the College of Arts and Sciences split. At the urging of then-campus leaders, especially the Dean of Arts and Sciences, by 2000 the School of Life Sciences became two separate organizational units: the School of Molecular and Cellular Biology (MCB) and the School of Integrative Biology (SIB).[39] MCB formed in part, from the support of administrators and affiliate faculty, to protect its share of NIH funding from reallocation

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[39] MCB is comprised of the Department of Biochemistry, Department of Cell and Developmental Biology, Department of Microbiology, and Department of Molecular and Integrative Physiology. SIB is comprised of the Department of Animal Biology, Department of Entomology, and Department of Plant Biology.

to less externally funded departments in environmental, ecological, and evolutionary aspects of biology.[40] At the same time, such an alignment helped MCB codify its positioning for federal R&D funding but also heightened the visibility of SIB where a faculty member in 2014 won the National Medal of Science. While MCB and SIB reflect structural adaptation within the academic core of colleges and departments, prompted by coalitions of campus leaders, SOI administrators, and faculty members, their development coincides with expansion in engineering and centers and institutes in the life sciences.

Surrounding national interest in nanotechnology, which started under U.S. President Clinton's administration in the 1990s, the Center for Nanoscale Science and Technology (CNST) in the College of Engineering was founded in 2001. Since nanotechnology applies to numerous fields and disciplines, CNST provides access to core facilities and equipment, organizes faculty research collaborations, and seed-funds other centers and institutes. Its building sits near the prestigious Beckman Institute for Advanced Science and Technology. By 2003 the College of Engineering established the Department of Bioengineering, which entails both biomedical and agricultural dimension of engineering. Though the Whitaker Foundation did not fund the department, its efforts in the 1990s to create biomedical departments nationally moved UIUC and the state of Illinois to form its own unit.

[40] Interestingly, when MCB was first conceived, it did not include the Department of Biochemistry from the School of Chemical Sciences. Yet department leaders advocated for joining MCB because, within the School of Chemical Sciences, it did not have much political or resource influence. The move to MCB benefited both the department and school, because biochemistry primarily received federal R&D funding from the NIH and its unit were position within a new school to increase shares of resource re-allocations.

With state and institutional interest in developing a biotechnology industry, the Institute of Genomic Biology (IGB) was formed in 2003. A *standard* institute under the Vice Chancellor for Research, IGB organizes affiliate faculty according to research themes in broad areas of systems biology, cellular and metabolic engineering, and genome technology that appeal to industry partners and mission agencies. The institute offers space and facilities for research teams, but is adaptive when it dissolves and creates new themes in line with funding opportunities. A *virtual* SOI, the National Institute of Child Health and Human Development Center for Research in Reproduction and Infertility formed in 2009 from a $6.8 million grant (plus matching funds from MCB). It includes faculty members from the Department of Molecular and Integrative Physiology (in MCB), the College of Veterinary Medicine, and Colleges of Medicine at partner institutions. While the grant is considered center-level—awarded to establish the center rather than to fund an individual investigator—its resources flow to already-existing laboratories on campus.

UIUC's NSF I/UCRC for Innovative Instrumentation Technology (CiiT) was formed in 2013, due in part to seed-funding from CSNT. It develops nanosensors for industry partners to detect bacteria in food processing (e.g., in powdered milk, beer, crops, etc.) and lead to application for human health (e.g., pharmaceutical screening). The Illinois Applied Research Institute was founded in 2013 to bridge academic researchers with industry partners and government agencies for unclassified and classified work. A *standard* institute, its offices are in UIUC's research park from which it organizes efforts to tap into established research infrastructure on campus. Finally, the NASA Astrobiology Institute: Institute for Universal Biology, also formed in 2013, represents structural adaptation in the physical sciences; with support from IGB, and in partnership with other institutions, it examines how life begins and evolves.

With UIUC's expansive size/scale, the sampled SOIs do not quite fit as neatly into a matrix as those at UVa. The various types of units, inclusive of centers and institutes, schools, and a department, can help promote the visibility of particular research areas and the institution. A campus leader articulated the predominant perspective well:

> I got my PhD so I didn't have to go into sales, and now I'm in sales. But that's essentially what we do, right? Even as faculty members…right? We have ideas, and we want to get people to give us money to pursue them, and so we have to sell them on your ideas. So we try to help faculty and faculty teams do that and whatever kind of centers they want to do.

But some faculty and departmental leaders questioned the extent to which academic structure matters for facilitating fluidity and continuity in research collaboration, grant dollars, and people. As one NIH-funded faculty member commented, "I was very involved with IGB when it first formed, which was…a genomics based institute, and in many different flavors from neuroscience, to plants, to energy production, to microorganisms, and…new antibiotics, but I actually am not a genomicist. So…I pretty well knew that that wasn't going to be a good move for me." While one SOI administrator found little correlation between academic structure and external rankings in biology, the respondent nonetheless observed that "universities as they're trying to figure out where they're going are thinking of ways to break those [departmental] barriers." Indeed, these quotations suggest variation—and a degree of conflicting perspectives—among campus leaders, SOI administrators, and faculty members that may underpin a relative lack of cohesiveness across SOIs.

Here, we may see as well some of the loose-coupling between institutionalization and resource position. UIUC is unarguably a legend in academic science. Its SOIs suggest commitments to increase resources, not because of perceptions of financial constraint, but to heighten its longstanding prominence. Indeed, a point of contrast between UIUC and UVa emerges. UVa is resource strong but evinces innovation from restricted deployment of funds. UIUC, a resource threatened institution, indicates innovation for additional money to uphold visibility and reputation.

Fear of Falling: "Things don't just stand still." Analogous to UVa, UIUC has been a longtime member of the AAU with its induction in the early 1900s. In 1907, UIUC president Edmund J. James hosted a campus visit for Harvard University president Charles Eliot.[41] Two years later UIUC was invited to join the AAU, as Harvard was closely involved in AAU administration. Over the years, UIUC has had 10 faculty members and 11 alumni win Nobel Prizes.[42] Dr. John Bardeen, a long time faculty member at UIUC in the Department of Physics, is the only person to win the Nobel Prize in physics twice: in 1951 for the transistor and in 1972 for the theory of superconductivity. Dr. Paul Lauterbur, who joined the UIUC faculty from Stony Brook University in 1985, won the Nobel Prize in 2003 in medicine for developing magnetic resonance imaging (MRI). At the institutional level, however, legendary status/standing as scientific powerhouse begets, especially for campus leaders, a fear of falling.

[41] Edmund J. James to E.H. Wells, December, 16, 1907, James General Correspondence File, 1904-1919; Record Series 2/5/3, Box 6, University of Illinois Archives.
[42] See http://www.law.illinois.edu/news/article/1037.

Perceptions among institutional leaders suggest concerted efforts to help UIUC buffer from threats of decline and continue to ascend in national prominence. An emeritus campus leader observed,

> …you're either moving forward or you're likely in a period of decline. Things don't just stand still. So what you look for both institutionally, but nationally in your relationships with your peers, there's always the question, well, "What's happening at Illinois? What are the exciting things that are going on in Illinois?"
>
> …So movement in one area such as the Beckman Institute begins to signal to the AAU and the national science community that things are alive, things are really hopping at the University of Illinois, and that's exactly the image that you want to create, and also that helps you retain and recruit faculty members. It helps you continue to build federal research support and obviously tends to build your reputation in the eyes of your peers.

Positioning for visibility, faculty recruitment, and research funding underscores the emergence of such wide-ranging SOIs at UIUC. But as a former SOI leader/current affiliate faculty member mentioned, such developments, to faculty members, are about not only money but also intellectual creativity and the social milieu on campus that renews and retains them.

Though, again, for an institution of UIUC's size/scope, the coordination of research across SOIs has been somewhat difficult. Consider the example of biology. Research in biology occurs throughout many different organizational units on campus: in MCB, SIB, bioengineering, nanotechnology, and the agricultural sciences. An SOI administrator described the "prairie mentality" that informs the diffuse spread across the expansive Mid-western campus of many "different flavors" of biology in all different areas. In 2007, an administrative unit formed under the Vice Chancellor for Research, the Division of Biomedical Sciences, to help campus leaders network SOI administrators, units, and faculty to collaborate to compete for federal R&D funding. With or without such organizing structures, the administrator elaborated, "in order to be competitive in the marketplace, you have to collaborate with others. You have to be trans-disciplinary."

Toward an Engineering-Medical Enterprise: "Universities listen to money." During the site-visit in fall 2014, campus chancellor Dr. Phyllis Wise, who was appointed in 2011, was reforming UIUC's strategic plan. A listening tour was underway, whereby new campus leaders asked for input from community members about new institutional directions, but it remained somewhat unclear what the most pressing priorities were. Nonetheless, it seemed that UIUC intended to capitalize on areas of interest to the state and generate select public investment in research opportunities. The example of the proposed stand-alone medical college at UIUC proves a telling augury.

The state of Illinois has a history of allocating funding for strategic, structural adaptations at UIUC. In the late 1980s, the now-legendary Beckman Institute was formed because it received money both from the principal donor Arnold Beckman and, with the governor's approval, the state. By 2003, the state contributed $73.5 million for the building for IGB and another $3.2 million for faculty hires in the biological sciences (Heckel, 2003). Moving forward, UIUC was proposing substantial state investment in a new medical college that aimed to integrate engineering, technology, and medicine. As one emeritus SOI administrator said, "The research side of biomedical engineering faculty found that they could get lots of NIH grants and so universities listen to money, didn't matter where the money comes from as long as they get money, sounds sexy." An engineering-oriented medical school, the respondent added from a competitive perspective, "would be a big win." In this way, the state would "win" in training doctors who possessed technological expertise and in serving the health needs of citizens in areas outside of Chicago, and UIUC and faculty members would also "win" in leveraging state money to finance efforts to increase their competitiveness for NIH funding.

Targeted state funding, particularly in capital projects, may suggest why UIUC does not necessarily evince a resource threatened position. Many of the research participants indicate the importance of capturing money and broadening the flow of research dollars to campus. Campus leaders and SOI administrators seem to favor the use of organizational structure to achieve these goals, while faculty members, perhaps unsurprisingly, evince some skepticism about whether SOIs do indeed lead to research collaborations. But, for the most part, participants at UIUC tend to view such organizational changes as enabling the continuance of strong scientific work on par with its heroes and Nobel laureates of the past. That does not mean a palpable arrogance at UIUC, rather a sense of loyalty and pride, underpinning the urgency and striving to live up to reputation.

Innovating in Quadrant III: Stony Brook University

Four themes underscore the SOIs at SBU in Quadrant III of low institutionalization/resource threatened. First, SBU gained early notoriety for biomedical research within the NIH and NSF arenas, and its SOIs within these delimited niches positioned the relatively young institution to ascend in reputation. Second, the SOIs largely constituted high-cost *standard* units for a still-developing institution in capacity for fluidity and continuity of research, money, and people. Third, resource constraints encouraged external partnerships, by way of SOIs, with Brookhaven National Laboratory and private donors to position to compete in STEM. Finally, the SUNY system and state-funding environment created a push-pull effect of momentum and restraint for ongoing development of SBU and its SOIs.

Federal R&D Profile: "Come with money in your hand." Founded in 1957, SBU has a striking record of early and ongoing success in STEM. Its late start in relation to most research universities in the U.S. may explain SBU's resource threatened position, though in productivity the institution has come to outpace many others in STEM research and graduate education (Geiger, 2010). New York's Gov. Nelson Rockefeller in 1958 championed SBU's early success, and ambitious president and physicist, Dr. John Toll, in 1965 sought to ensure that the institution became a University of California—Berkeley of the East (Gelber, 2001; Geiger, 2010). SBU, though more like Universities of California at San Diego and Santa Barbara than UC-Berkeley**,** was considered by 1995 a top research university in the Northeast (Diamond, 2010; Diamond & Graham, 1995) and later joined the AAU in 2001. Long-standing strengths in biomedicine continue to position the university for prominence—in federal R&D funding from NIH and NSF. As Figure 10 shows, the majority of federal R&D funding to SBU comes from NIH. In median percent of federal R&D funding over time, the institution receives 56% from NIH, 27% from NSF, and 7.5% from DOE. About 3% each comes from DOD and NASA, and less than 1% each comes from USDA, DOT, EPA, and a variety of other mission agencies.[43]

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[43] The variety of other mission agencies that provide federal R&D funding to SBU consists of the Agency for International Development, Department of Commerce, Department of Education, Department of Health and Human Services (Centers for Disease Control and Prevention, Food and Drug Administration, Health Resources and Services Administration, and Other), Department of Housing and Urban Development, Department of the Interior, Nuclear Regulatory Commission, and the Social Security Administration.

The nine sampled SOIs reflect change and adaptation concentrated within the biomedical, physical, and life sciences. Of these, five centers/institutes and one academic department have direct connections to medical and pharmaceutical arenas and thus the NIH and NSF. A fifth center focuses on computers and another on information technology, broadening the scope of STEM initiatives around the DOE and state interests in and money for economic development respectively. Interestingly, one center included in the study has enough privately endowed resources to preclude it from having to compete for federal R&D funding. The emphasis on centers and institutes at SBU suggests a strategy to secure larger and longer grant-funded research projects than otherwise could have likely been undertaken. Though increasingly competitive, the NIH money aims to sustain a major research project toward clinical application and lasts on average for five years. Yet the centers and institutes and academic department, while relatively recent and new developments at SBU, reaffirm early commitments in STEM.[44]

[44] Recall that Kraatz and Sajac (2001) suggest organizations are more likely to invest in areas of historic strength and commitment because such investments are less risky than new pursuits. For SBU, a position of resource threat may inspire organizational change and adaptation but in and around already-established strengths. In this way, SBU innovates and balances risk and cost of new pursuits.

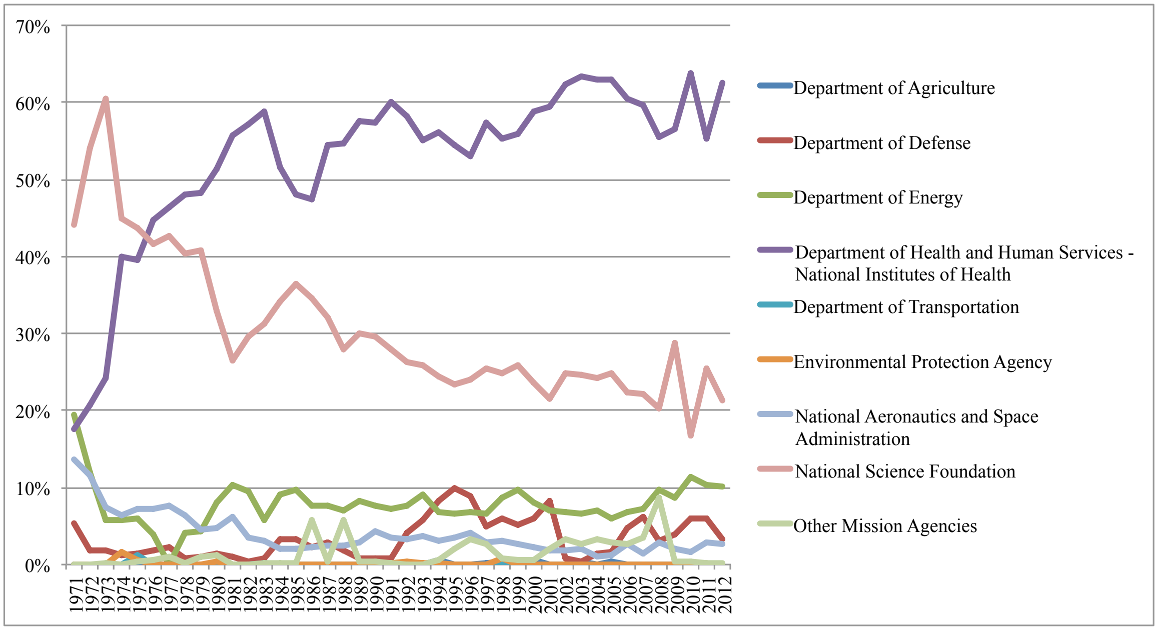

Figure 10. Percent of federal R&D obligations to Stony Brook University, by mission agency, 1971-2012. *Source:* National Science Foundation, *Survey of Federal Research and Development Obligations.*

SOIs at SBU aim to heighten their own and the institution's visibility and open channels for additional federal R&D funding. Though "low institutionalization" and "resource threatened," SBU has a strong reputation. An SOI administrator observed, "We're only hiring people that are funded and that demonstrate fundability. …Most departments I know are requiring that you come with money in your hand, and this is NIH money, NSF, American Heart Association." Reputation helps to build a research core of federally funded faculty members, but preparedness for emerging funding opportunities also contributes to SBU's competitiveness. In the early 2000s, when the government and general public feared bioterrorism, an influx of money from the NIH went to bacteriologists. SBU campus leaders had invested in capital projects to anchor emerging research centers and, at the time of heightened national concerns over bioterrorism, had the researchers, equipment, and facilities organized to compete:

> Well, this was 2003. [There were the terrorist attacks of] September 11th and then the whole anthrax thing and then the overreaction of the United States into putting zillions of dollars into biodefense. And I feel a little bit unclean in saying this – in effect, we benefitted a lot from it. (SOI administrator)

But positioning around areas of strength—and the NIH in particular—has drawbacks. A faculty member said, some centers are "feeling the pain a little bit as that money's contracting…we've been paying the price recently." The relatively low resource base at SBU thus makes centers and institutes in particular reliant on external funding to sustain research agendas.

The SOIs: "A way of getting the resources together." The formation of the nine sampled SOIs at SBU suggests an intriguing pattern of development. As previously noted, eight are centers and institutes and one an academic department. Four SOIs—more than one-third of the sample—were founded in 2000, one year before SBU was invited to join the AAU. Those founded after SBU joined the AAU indicate purposes analogous to their earlier counterparts: alacrity of the young, ambitious but cost-sensitive institution.

In 1999, the Centers for Molecular Medicine was founded. It entailed a new building on campus that would come to house four centers: the Center for Developmental Genetics, the Center for Infectious Diseases, the Center for Structural Biology, and the Center for Cancer and Cancer Genetics. Of the four, only the Center for Cancer and Cancer Genetics failed to launch because it had strayed some from the core medical and academic strengths of campus. While the other three pulled from faculty members and project teams already at SBU, the Center for Cancer and Cancer Genetics aimed to form based upon a new hire and emerging niche. SBU did not fill the position. Yet the other three centers were created and formalized around 2000 as *standard* units with faculty member offices, laboratories, and facilities. They were constructed to facilitate open laboratory spaces that encouraged "collisions" and collaborations among researchers, an SOI administrator explained. Additionally, the researchers shared materials, such as sucrose, in order to lessen the costs of conducting science. Its approach differs from that of UVa: recall that UVa has a number of *virtual* centers and institutes to minimize institutional investments. But as new-comer to the AAU, SBU suggests needs to build-up facilities to develop infrastructure to advance knowledge yet must do so within tight budget constraints.

As testament to SBU's commitment to the biomedical arena, its College of Engineering formed the Department of Biomedical Engineering in 2000. Though it missed the early round of start-up funding from the Whitaker Foundation, the College and department vied for money from the foundation for capital costs. For the four SOIs formed in 2000, SBU mostly drew on institutional resources for front-end investments. When a proposed center was aligned with state goals for economic development, it might attract targeted state dollars. For instance, the state of New York selectively allocated money to form, in 2003, the Center of Excellence in Wireless and Information Technology (CEWIT) in SBU's research park. CEWIT leverages its technology, including a visual computing center, to attract industry and federal government partners, and it continues to receive a hard-money line from the state because CEWIT serves New York's economic development plan to nurture nascent companies and create jobs.

With advancements in the early 2000s in the then emerging field of chemical biology, the Institute for Chemical Biology and Drug Discovery (ICB&DD) was founded in 2004. It leveraged connections with academic departments in the physical sciences, SBU's medical college, campus centers and institutes, near-by national laboratories, and industry partners to develop pharmaceuticals for clinical trials. Interestingly, ICB&DD is the only *virtual* institute included in the sample of SOIs at SBU. Operations and laboratories are in existing affiliate departments. While the institute reports to the Provost and receives some institutional support, its utilization of established infrastructure on campus helps it keep overhead costs low. Yet the virtual formation fosters boundary-spanning and drives the need to reach-out across and beyond the campus for involvement from researchers at numerous organizations.

In 2008, from an $8 million gift from a donor and his wife, the Laufer Center for Quantitative and Computational Biology was founded. The money supported the capital investment in the center and endowed the directorship and faculty lines. Focused on computer modeling of biochemical networks in cells, the center aims to sustain itself on research grants. Private philanthropy also led to the creation of the Simon's Center for Geometry and Physics in 2009. Its benefactor, retired hedge fund manager Jim Simons, has a direct link to SBU as an emeritus faculty member and chair in mathematics. By way of his foundation he gave over $100 million to the Center. Because of such robust resources the Simons Center, a *standard* unit, does not actively compete for federal R&D funding. Private money precludes the center from federal R&D competition in mathematics and physics where funding levels are relatively low and the success rate for grants small. Finally, in 2012, the Institute for Advanced Computational Science was formed based on one anonymous donation of $10 million and a matching gift, from Jim Simons, of another $10 million. The Institute develops analytical capabilities for big data—and external fundability in emerging, key scientific niches. It reports to the Provost, collaborates with the Brookhaven National Laboratory for DOE-grant funding, and can direct some projects (e.g., running simulations of surgical procedures) toward the medical enterprise and NIH.

The sampled SOIs cover SBU's primary, longstanding federal R&D funding bases of the NIH and NSF. As one faculty member observed, the emphasis on clinical application in some of the centers and institutes can offer an advantage in pursuits of NIH money. Some of the research undertaken on campus, for instance, pertains to "asking the question, 'Can I give enough drug to cause the effect that I want without causing effects that I don't want?' the respondent elaborated. But overall the SOIs in this thesis seem to work together amid some overlapping research goals and funding agendas. An SOI administrator explained that a center "was originally conceived as a way of getting the resources together, to put together something where [faculty members] would have access to the tools that we use in…biology." The access to facilities and equipment—important resources for research—has been helpful to boosting the fluidity and continuity of cross-campus collaboration. Yet some faculty members question whether centers and institutes form new research efforts and funding streams that could not otherwise have happened. Seven of eight centers and institutes at SBU are bricks-and-mortar, perhaps to show legitimacy in pursuits in STEM and stave off criticism that "some of the naming just comes because of how the granting agencies work," a faculty member said. "They say we're going to fund a 'center,' and so you have to call yourself a center because that's what they're saying they're going to fund."

The Bricks-and-Mortar Approach: "People like big flashy things." Analogous to UVa and UIUC, SBU has structural and historical influences that position it somewhat distinctively in STEM. In addition to having a medical and health sciences center across the street from the main academic campus, it has proximity to DOE's Brookhaven National Laboratory. The location—and long-standing partnership—provides competitive advantage for SBU and the national lab alike. As one emeritus campus leader observed, SBU's taking over the management of Brookhaven National Laboratory "was important for medicine as well as physics" research. Centers and institutes on campus helped to foster the research connections and make increasingly permeable SBU's organizational boundaries, and at the time of the site-visit in 2014, some scientists from Brookhaven also had faculty appointments and contributed to projects in key, funded-areas such as imaging for human health.

The latitude of centers and institutes to deepen relationships with Brookhaven and other external organizations helped to raise the national profile of SBU. Centers and institutes in particular promoted highly visible research efforts. According to one SOI administrator, institutional leaders tended to champion bricks-and-mortar centers and institutes as such organizational forms are "big flashy things:"

> I think it's that people like big flashy things. You know, if you're a provost or a president and you want to go out and sell the university, you can't say, "Hey, look, we modified English 203 this year." You know, that doesn't sell. Whereas if you say, "Hey look, we got a building, we've got research, it's going to cure cancer," that's what they would love to say. We don't do that, but that's what they would love to say. And so I think it's just big flashy things. Big institutions like big flashy things. National Institutes of Health…I used to have a lot of involvement with them for some federal research funding. And they have the same problem. When they go to Congress, when the head of NIH goes to Congress, you know, Congress is asking why did you not cure cancer this year for us when

> we put $30 billion a year into you guys, why haven't you done *this, this,* and *this*? And so organizations like that need big flashy things to be able to sell, and so—bigger tends to be flashier.

Such a perspective suggests the prestige that can come from SOIs (especially "big flashy" centers and institutes), whether they lead to tangible advancements in research or not. Of course, those involved in SOIs believe in the efficacy of their organizational units though they also recognize it may take time to show results in federal R&D funding.

Early and contemporary philanthropic donors to SBU have profoundly shaped the institution's academic structure. Philanthropist and businessman Ward Melville donated from 1957 to 1969 approximately 811 acres of land to establish the university's location in Stony Brook, New York (Gelber, 2001).[45] In recent years emeriti faculty members have given $115 million to adapt the research core, a modest amount in comparison to high-profile philanthropic gifts at elite private institutions but nonetheless impactful at SBU. As noted above, the Laufer Center for Quantitative and Computational Biology was started in 2008 from a $10 million gift from a former professor and his wife. The Institute for Advanced Computational Science, formed in 2012, received $20 million in endowed gifts to establish its research infrastructure, faculty lines, and director position. The Simons Center for Geometry and Physics received $105 million from former chair of the mathematics department Jim Simons, making for the single largest gift ever to SBU. Private support aimed to extend SBU's longstanding "visibility and prominence" in physics and math, a campus leader said. The respondent added that Jim Simons thought a center would "raise the visibility and quality of Stony Brook in those two areas even higher, and he wanted to do something for a university that he felt he owed a great debt

[45] Gelber suggests Melville spread the donation of land over a number of years for tax purposes.

of gratitude toward." Here, we see the importance of campus leaders who pursue philanthropic gifts for investment in the research infrastructure of the institution.

The relationship with Brookhaven National Laboratory, further prompted by campus leaders, and the leveraging of private donors suggest important recourses to organizational change and adaptation for SBU and its SOIs. As resource threatened, the institution must pursue its goals on the margins and reach beyond itself for support and money to innovate. Interestingly, SBU has nimbleness that others in the study do not. It has a reputation based on short but prominent history, and it also seems to have some alacrity from being "low institutionalization," that is, from being a relatively young institution and newer, less-engrained member of the AAU. There is latitude and a direct aim to build-up capacity, and resource threat, though a hindrance in some ways, may help campus leaders make convincing appeals to donors.[46]

Holding Its Own: "That's still the reputation." SBU suggests both youthfulness and maturity. Within the context of AAU universities, the institution is the most recently founded. But it did not take long for SBU to establish a national reputation. An emeritus campus leader recalled a key faculty hire that SBU's second president, Dr. John Toll, made in 1966, a hire that contributed to the institution's ascendancy in science: "[O]ne of the first things that was done was that [the second] President John Toll brought in Chen-Ning Yang, the first Chinese Nobel Prize winner in physics." While SBU has broadened its programs and research agendas, the respondent added, "that's still the reputation."

[46] See Pérez-Peña (2011), who reported that Jim Simons donated to Stony Brook in part to spur state investment in the public research university.

The State University of New York (SUNY) System, which celebrated its 60th anniversary in 2008, has been reluctant to name a flagship institution.[47] But SBU has been an important focal point of New York's SUNY 2020 strategic plan. In 2011 the state awarded $140 million for capital projects to leverage private industry to build regional infrastructure around four SUNY graduate centers—Albany, Binghamton, Buffalo, and Stony Brook—for economic development.[48] The plan also gives some financial autonomy to each center to set tuition prices.

While the governor's office and SUNY system seems to push forward SBU's development, they have also been known, historically, to slow the pace of change and adaptation. From budget cutbacks to public higher education in the 1990s, many of the SUNY campuses declined in quality. A former system official explained that "the problem comes when you have presidents and chancellors who keep saying to the public in general and to their governors and legislatures that if we keep getting cut like this, we're going to have to do something bad. Well…. We've been doing it bad [and] it's not 'we're going to have to,' we've done it and it's hurt us. And we are in fact a lesser university." The administrative and political structure of the SUNY system can impede institutional advancement. Another former system administrator commented that in some states, approval for a new program could take merely months, while in New York, "you had to get every university in the state to approve it."

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[47] SUNY delegates did not want to follow other state systems in designating a flagship institution (Gelber, 2001). In his 2008 state-of-the-state address, Gov. Eliot Spitzer referred to New York's two AAU members, SBU and Buffalo, as "flagships" because of their prominence and to encourage their further involvement in regional economic development. Recently, the SUNY campuses in Albany, Binghamton, Buffalo, and Stony Brook are considered "SUNY centers."

[48] See http://www.suny.edu/impact/business/nysuny-2020/.

Without doubt, SBU is not alone in responding to state and system finance and governance. UVa and UIUC pursue change and adaptation in light of their policy (and political) environments. Certainly the withdrawal of state funding to SBU over time constrains available resources for competition in STEM. But the prevailing mood on campus does not necessarily indicate a resource threatened position, but rather, on the whole, one of opportunity. In some ways, the resource threatened position is part of SBU's history and therefore undesired but normalized. It motivates the institution to innovate, and the nature of innovation focuses on capacity and infrastructure by way of *standard* SOIs. Financial need does make an appeal to donors, who have consistently over 58 years helped the institution gain in status/standing and wealth. Such an approach may not necessarily be sustainable, but early successes suggest reasons for optimism and ongoing, albeit targeted, allocations from the state to develop the institution further. In this way SBU has a distinct role in the SUNY system and can continue to hold its own in American higher education. And its position as institution-on-the-rise, encouraged by intensive involvement of campus leaders, seems to inspire loyalty among—and continuity of—faculty members: Nobel laureate Dr. Yang, whom then-president Dr. Toll had recruited, stayed at SBU for 34 years from his arrival in 1965 to retirement in 1999 to run the C.N. Yang Institute for Theoretical Physics.

Innovating in Quadrant IV: University of Florida

Four themes underscore the SOIs at UF in Quadrant IV of low institutionalization/resource strengthened. First, SOIs developed in longstanding NIH-funded areas of strength, serving to converge further the academic and medical cores to codify UF's national reputation. Second, the eight SOIs largely aspired to coordinate research efforts on campus, though the degree of ties for fluidity and continuity of research, money, and people was somewhat disjointed. Third, the structural characteristics of UF, as a flagship, land-grant, and medical institution, provided a distinct vantage point yet also barrier for national prominence. Finally, targeted state funding for strategic faculty hires aimed to affirm UF's greatness, but strong resources were likely not enough to innovate for competitive goals.

Federal R&D Profile: "And so it's a bigger pot of money." UF has consistently received its largest share of federal R&D funding from NIH. As Figure 11 shows, funding from the mission agency rises and falls over time, but outpaces all other federal R&D sources. In median percent of funding over time, the NIH provides 49% of UF's overall federal R&D money. The interdisciplinary collaborations on campus between the medical sciences and engineering can make a compelling case for grant dollars. Such research may leverage technological developments for solutions to health problems and clinical trials. Yet fundamental research at UF, even in applied areas such as Engineering, provides opportunities for NSF funding. Indeed, UF receives 15% of its federal R&D funding from NSF. It also receives 12% from USDA, 11% from DOD, 4% each from DOE and a combination of other mission agencies, 3% from NASA, 1% from EPA, and less than 1% from DOT.[49]

[49] The combination of other mission agencies from which UF receives federal R&D funding consists of: the Agency for International Development, Department of Commerce, Department of Education, Department of Health and Human Services (Centers for Disease Control and Prevention, Centers for Medicare and Medicaid Services, Food and Drug Administration, Office of the Assistant Secretary for Health, and Other), Department of Housing and Urban Development, Department of Labor,

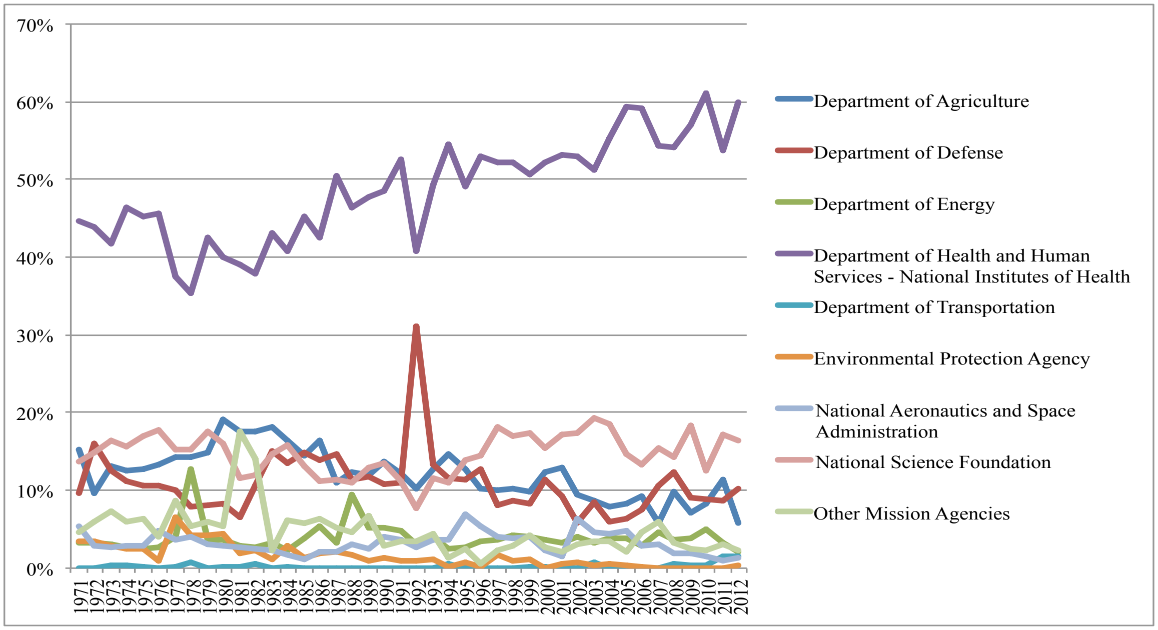

Figure 11. Percent of federal R&D obligations to University of Florida, by mission agency, 1971-2012. *Source:* National Science Foundation, *Survey of Federal Research and Development Obligations.*

The eight sampled SOIs at UF suggest even closer positioning than in the past of academic structure around the NIH and NSF. Of these SOIs, six are centers and institutes and two are academic departments that reflect an intended matrix links to other traditional academic departments. The wide-ranging involvement among campus units could open new sources and flows of research, money, and people. As one SOI administrator described the process of gaining support from department chairs,

> So if it meant that faculty in their department had a better opportunity to secure NIH funding in particular, because if you're in materials or in electrical, or you're in mechanical and aerospace, NIH funding looks a lot more attractive than NSF funding. NSF funding levels are lower normally per project so normally if you've got two or three investigators, then you might have 100,000 per year per investigator, including indirect costs. With the NIH, it probably

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Department of the Interior, Nuclear Regulatory Commission, and Office of Justice Programs.

> maxes out about 250,000 to 300,000 a year for direct costs and indirect costs are on top of that.
>
> And so it's a bigger pot of money, [and] they tend to run for a longer time because you've got the goal in the end of either maybe going into a clinical trial or at least having enough data to justify taking it to the next level. And so they tend to run for five years as opposed to two or three. So that's attractive if department chairs think they can leverage that kind of support.

Such a perspective suggests the *shared* interests of administrators and faculty in competing for the "bigger pot" of NIH money in comparison to all other mission agencies. Not all faculty or SOIs pursue projects that meet NIH goals of advancement to clinical trials to treat diseases. In this way, the NSF remained a prime, though somewhat less lucrative, target. Some SOIs, an administrator of one explained, were called to support investigator and team proposals to help articulate an increasingly important area to the NSF: the "innovation" benefits that could come from the research.

Analogous to UVa, UF innovates from a resource-strengthened position in federal R&D funding. Both institutions suggest ongoing commitments to longstanding funders and scientific areas of expertise and specialization. Yet UF has a size/scale advantage and disadvantage. While UVa's SOIs largely constitute a tight network of organizational forms, UF's SOIs aim to connect a diffuse spread of units across a massive campus. They aspire to extend a stronghold on NIH money and thus mostly focus on boundary-spanning between engineering and medicine on campus.

The SOIs: "*Research goes all over the place*." The sampled SOIs at UF suggest an intriguing range of adaptations surrounding medicine and engineering. There has been movement within the core of academic departments, resulting in two relatively recent units included in this study. But most developments are centers and institutes that aim to link to the longstanding, embedded academic structure. Because "research goes all over the place," a campus leader explained, centers and institutes can provide an option for institutional leadership to facilitate and support interdisciplinary work.

As reported above, the eight SOIs at UF consist of six centers and institutes and two academic departments. With a $10 million gift from Dr. J. Crayton Pruitt and his family, the College of Engineering formed the Department of Biomedical Engineering in 2002. The College resisted the money and influence from the Whitaker Foundation in the 1990s to form the unit, but acquiesced under a change in college leadership, the Pruitt family donation, and interest in organizing research to compete for biomedical money. In 2005, with support from the College of Engineering, the Nanoscience Institute for Medical and Engineering Technology (NIMET) was formed. A bricks-and-mortar, *standard* organization, it brings together researchers from the medical college and engineering and provides access to equipment and facilities for research. As part of university-wide efforts to create freestanding research institutes and centers, which would report to the Provost, the Emerging Pathogens Institute (EPI) was founded in 2006. EPI, analogous to the IGB at UIUC, receives a hard-money line from the state because of public interest and social benefits from life sciences research. A *standard* institute, its building houses administrative offices, laboratories, and faculty offices; however, its reach in terms of personnel is expansive and includes affiliate faculty from many of the life sciences departments on campus.

By 2007 the NSF I/UCRC for High-Performance and Reconfigurable Computing (CHREC) was developed, entailing a multi-institution partnership with UF as lead and membership from private industry and NASA sites throughout the U.S. The center works to develop computers that can withstand radiation to operate in space and with hardware necessary for unpredictable, high-stress environments. Its operations reflect the *standard* center, with offices and laboratory space in an academic building. Yet another *standard* unit, the Clinical and Translational Science Institute (CTSI), founded in 2008, bridges medicine and engineering; materials engineers, for instance, work on projects of benefit to surgical patients. The unit is located on the main campus and within close proximity to the medical enterprise.

Over a five-year period from 2009 to 2014, UF has had three intriguing structural developments. First, the Department of Environmental and Global Health, was formed in 2009 in the College of Public Health and Health Professions. It works with EPI and suggests in research areas, which focus on transfer of pathogens among the environment (e.g., plants and water), animals, and humans, an outgrowth of medical sciences. Second, in 2011, the Engineering Innovation Institute was formed in the College of Engineering to oversee educational initiatives and contribute to research grant projects. With money and space allocated from the college, the institute reflects a *standard* unit. Finally, one of the latest institutes to form, also in the College of Engineering, was the Institute for Cell Engineering and Regenerative Medicine (ICERM). While ICERM pertains to engineering research, its work is fundamental and thus appeals to NSF funding. A *virtual* institute, its overhead is low, and it requires minimal departmental and college investment.

A number of faculty members and administrators have affiliations with multiple SOIs. The interconnections suggest advantageous opportunities for research and grant funding. Some campus leaders indicate the challenge of coordinating so many units at such a large institution, while others point to balancing, as one campus leader explained, the "grassroots" of faculty-driven initiatives and "administration level looking over the landscape of expertise and saying, 'You know, where should we form some institutes?'" For faculty, however, consideration of joining centers and institutes in particular can be met with a degree of hesitancy and, in some cases, explicit resistance. Capturing the predominant perspective, an affiliate faculty member explained that centers and institutes can facilitate communication among researchers though not always collaboration: "[If] you see a center or institute on paper, to me, really the only guarantee is that they have each other's e-mails."

In this way, the diffuseness of UF works for and against it. It has great depth in organizational capacity and strong resources, which can together position UF to ascend in research prominence. But campus leaders confront the barrier of *coordination*, how best to align SOIs, SOI administrators, and faculty members toward strategic goals. For an institution of such size, scope, and scale, the *localized* actions of faculty members and units appears to determine the implementation and success of research initiatives. What is more, a tension between institutionalization and resource position seems to magnify campus politics and resistance toward collaboration. UF strives for eminence (e.g., moving from "low" to "high" institutionalization in the AAU) and has some money to finance strategic change, yet its ambition to improve in status/standing may heighten the competition on campus over what stakeholders perceive as constrained resources. Thus network connections across SOIs appear largely uneven at UF, possibly hindering its momentum and efficiencies.

The Flagship-Land-Grant-Medical Institution: "Very unusual to find all of that on a single campus." The structural characteristics of UF offer a distinct vantage point from which to pursue organizational change and adaptation. A state flagship and land-grant research university, UF has an expansive range of colleges and departments on campus. It has a contiguously located medical college but also a relationship with the medical college in Jacksonville. As one SOI administrator put it,

> University of Florida is a huge university…with 16 colleges on a single campus. We are the land grant university, as well as the flagship university, as well as the leading medical center. And that's very unusual to find all of that on a single campus. The university administrators were very concerned about being able to maintain…and foster interdisciplinary research within this setting because it's very easy to get lost within the individual colleges, particularly in such a huge university. I mean, the bigger it is, the easier it is to get lost. So the university has placed a strong focus on the development of freestanding, interdisciplinary research institutes.

Such a perspective suggests a size/scale advantage, of having experts across disciplines and fields, which centers and institutes may help the institution leverage. Interestingly, the Departments of Biomedical Engineering and Environmental and Global Health each boundary-span in research and integrate the medical enterprise and academic core. While these SOIs may reduce the probability of getting "lost" on campus, it remained unclear whether they were effective in capturing *additional* NIH dollars not otherwise gotten.[50] But success-claims persisted. According to one faculty member, who sought input from

[50] Analytically, it may be difficult to evaluate the success of any given SOI or set of SOIs (as measured by federal R&D funding). SOIs could, in annual reports, list as part of their external funding totals the full grants awarded to affiliate faculty members. But in practice the SOIs may only receive percentages of these grants. When grant-funded faculty members move from one institution to another, their funding follows them. Some SOIs may claim this—the successful recruitment of faculty members and new influx of money—as "wins;" however, the SOIs have not necessarily *caused* or *helped* these faculty members to secure the funding. Federal mission agencies award some center-level grants, which for these recipient SOIs may be a somewhat straightforward marker of success. Yet careful empirical attention must still be paid to costs associated with pursuing grants, baseline levels against which to measure success, and comparison groups by which to understand whether these SOIs relative to others have increased institutional shares of funding not otherwise captured. I address this further in Chapter 7.

a surgeon on research: “I knew that we could immobilize quaternary ammonium compounds on the surface that would kill bacteria from some earlier work we had done, and so we tried making a bandage that way and it got licensed, it formed a company and took off.”

The Cost of Eminence to Compete: “Why are they leaving?” With targeted funding from the state, UF leadership launched the Preeminence Plan in 2013 to raise its national profile and ranking. Indeed, UF’s entrance into the AAU in 1985 recognized and added to the institution’s clout. Within a few years, however, some on campus doubted whether UF was “great” akin to the elite private universities.[51] Questions of greatness have persisted over the years, and the most recent round of strategic initiatives focus on faculty hiring to attract and retain top scholars across disciplines and fields. Departments throughout the colleges on campus can submit proposals to central administration to win allocation of money for faculty lines and, for a five-year period, state-covered faculty salaries. UF has embarked on an $800 million fundraising goal, but the state has upped its contribution from an initial $15 million a year for five years to $20 million per year over its committed funding cycle. State money matters because it can, for scientists and engineers, pay for salary and some initial start-up costs that do not otherwise have to come from external grants. While the majority of funding and lines has gone toward STEM areas, it may not be enough to help an already resource-strong UF to compete.

Faculty members are quick to highlight the emphasis on recruitment versus support of current researchers on campus. As one senior faculty member observed,

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[51] See Lester’s (1987) article in the student newspaper in which UF’s greatness is questioned.

> I think you're not helping faculty grow and thus what we see today is faculty are leaving. They come in, they get a great start up package, and within four to five years they go to another university, get another start-up package. Why are they leaving? Because the institution they're in doesn't value [them] when they are there enough to convince them to stay.

The demonstration of "value" suggests a cultural dimension of support and collegiality, but also money. An associate professor explained how "they spend, I don't know, maybe $500,000 to bring somebody in. Well, $500,000 could buy one or two pieces of equipment that could help dozens of people across campus do much more effective things, you know?"

The expense of attracting and retaining top talent in science is costly. The state financing of salaries can be helpful, yet allocation under the Preeminence Plan has a cut-off after five years. An emeritus campus leader explained: "Make sure you understood that—[it's] for five years. For five years. It's not recurring forever…I mean, it's not like they gave them $15 million recurring." As another faculty member noted, to try to outspend both elite public and private institutions "to compete on somebody else's terms is just not the way to go. …[UF] needs to think about how to leverage their own strengths and build sort of a different brand." The competition for emerging stars can be fierce. A relatively new SOI administrator observed: "In some sense, the top universities select for phenotypes that are super ambitious." To attract the "super ambitious," the "careerists," the respondent elaborated, requires money and a cultural commitment on campus that values and incentivizes eminence.

Analogous to UVa, a resource strengthened position does not necessarily translate into perceptions of robust financial bases. The departure of rising faculty stars from UF suggests an issue of money but also prestige. Among some public institutions, UF may not have the resources to retain the best in STEM because the best are the most expensive to keep. Compared to elite private institutions, and increasingly as the resource-disparities by institutional sector has deepened since the 1990s, UF will likely come up short in their financial offers or matches to key faculty members. Yet the luring of faculty members, of "careerists," to the longstanding elite may indicate the role of institutionalization in science. Eminent researchers want professional latitude and, often, affiliation with other elite scientists and institutions. Indeed, UF has a number of eminent scientists, endowed chairs and professors, and talented junior faculty members. It can attract and retain strong researchers, but UF's responsiveness to its *aspirational* competitors may make the institution feel resource-constrained. In this way we may see alternating periods of (1) fluidity and continuity and (2) atomization and disjointedness in research, money, and people on campus.

Summary

As the within-case findings of SOIs suggest, UVa, UIUC, SBU, and UF innovate across the spectrum of status/standing and resource position. Institutionalization and resources can differentiate recourse to structural adaptation, though in some unexpected ways. In Quadrant I, UVa features almost entirely *virtual* centers and institutes, which keep institutional investments minimal amid state funding declines and aim to maximize possible external funding. In Quadrant II, UIUC has a mix of unit-types, reflective of the great heterogeneity of disciplines and fields on campus. Because of perceived threats of falling in prestige it explicitly seeks to boost federal R&D money for viability and visibility, and incremental shifts in the research core intend to bring about fundamental change in engineering and medical research for NIH dollars. In Quadrant III, SBU suggests tight resources but an ambitiousness of youth. It has established, since its founding 58 years ago, a national reputation for research that offers leverage for external partnerships. SBU must continue to look outside of itself—to donors, the Brookhaven National Laboratory, and the state—to piece together money to innovate. The emphasis at SBU on *standard* units suggests structural developments for legitimacy and research capacity to compete. In Quadrant IV, UF has the space, capacity, and resources to accommodate a number of standard centers and institutes and also new academic departments. Yet questions remain about (1) whether centers and institutes can help coordinate research collaborations and (2) whether UF, caught between low institutionalization and high resources, has enough clout and state backing to compete among the most elite institutions. Findings from the cross-case analysis are presented next in Chapter 6.

CHAPTER 6

CROSS-CASE FINDINGS

This chapter reports six themes by which the cases (the SOIs) vary across the four sampled institutions. It seeks to add some robustness to our understanding of SOIs, building toward a stronger set of empirical conclusions than the within-case analysis can alone provide. Such an approach aims to indicate the depth and dimension of structural change and why the manifestation of change occurs in the way that it does. An overview of the six themes is provided here, followed by a brief discussion of how they illuminate the research questions as outlined in Chapter 4. Then each theme is presented with supporting evidence and subsequently summarized, together, in this chapter's concluding section.

There are six core empirical themes that cut across the sampled SOIs at UVa, UIUC, SBU, and UF. First, the SOIs suggest organizational units that are *competing to survive as political experiments.* With exception of schools and departments, SOIs are largely formed as short-term adaptive (e.g., experimental) organizational units and thus meant to form and dissolve as needed. Yet once created, they seem to take on lives of their own. The pursuit for longevity may come from their infusion of values, money, and people, which are core resources to protect, and efforts to endure could find support in SOI-level discretion over planning. They do not always aspire to complete self-autonomy; after all, SOIs do fall within reporting relationships of organizational hierarchy. But they are political in guarding self-interest for survival and experimental as unproven, though heavily relied upon, organizational forms. Second, SOIs appear to be predominantly *serving the medical enterprise*. Not all SOIs in this study focus on biomedicine, but by and large the majority seem to orient the academic heartland toward this NIH-funded arena. Here, the medical enterprise comes across as hegemonic-like, subsuming organizational structures and emerging specializations within STEM disciplines and fields.

Third, the SOIs suggest aims of *positioning to co-opt federal funding streams.* Though not quite focused on aiming to steer federal mission agencies, the SOIs in this study can facilitate exchanges between the scientific community and research sponsors. They also raise the prestige of faculty members' research, providing a mechanism to heighten an investigator's leverage in panel reviews and also to earn invitation to join panels as reviewers. In short, the SOIs appear to support the certification of faculty members as experts, as specialists in niche-areas who seek to influence external funding to finance/legitimize their work. Fourth, the SOIs are *strengthening prestige-claims among the academic elite.* SOIs can help campus administrators tout research prominence in specialized areas of science, deepening institutionalization (e.g., embedded standing) in a field whose membership includes some of the most elite institutions in the U.S. At the same time, SOIs provide a platform for faculty members to solidify credibility in emerging fields and disciplines that may, if effective, increase the likelihood of securing research funding.

Fifth, the SOIs suggest mechanisms of *privileging access to administrative/financial authority.* As part of their nature and emergence, SOIs, on the whole, can collapse boundaries between administrators and faculty members. For instance, faculty members can initiate new SOIs by way of seniority and research accomplishment. Already-formed SOIs may change leadership periodically, and they tend to feature administrators whose research programs have been well-funded and continue to hold relevance with mission agencies. In this way scientific experts/specialists gain disproportionate advancement to leadership positions with financial responsibility/authority, but some could be vulnerable to over-utilizing SOIs to advance individual research agendas.[52] Finally, the SOIs seem to be *mediating the ascendancy of academic capitalism.* Faculty members want to produce strong scientific work and need *fluidity* and *continuity* of resources to sustain their research programs. Indeed, some may pursue partnerships with industry for money for research and to leverage in competitions for federal R&D funding. But such competitive drives, which underpin entwinements with industry, do not necessarily mean that faculty members do anything for money or profits. Instead they seek resources to cover the cost of running laboratories and to garner legitimacy for nascent areas of work at interstices of fields and disciplines.

The first and second themes address the nature of variation of SOIs across the four institutions (RQ1). SOIs in this study vary within and across campuses, in part from institutionalization (e.g., embedded organizational structures) and politics and money. While the SOIs differ in form and business models, they do tend to converge around medicine. The third and fourth themes pertain to environmental influences on the emergence of SOIs (RQ2). There are clear links between SOIs and federal R&D funding,

[52] Advancement to administrative positions may hold symbolic value. Not all SOIs provide access to *increased* resources and formal authority, but their leaders could, at least in job titles, still reflect elevated status/standing as experts and specialists.

and most SOIs in this study respond to and also aim to shape external funding priorities/outlays. From SOIs the scientific community enters into exchanges with mission agencies and positions for success in panel reviews. The fifth and sixth themes illuminate the campus-level influences on the emergence of SOIs (RQ3). As expected, administrators and faculty members diverge somewhat in their regard for the AAU. But overall they suggest SOIs as facilitating pathways toward administration with symbolic advancement in status/standing and also particular access to financial resources/stewardship. Ultimately we do not see outright resistance to academic capitalism, but some market efforts for fluidity and continuity in funding for research. Further elaboration of these and other implications are discussed in Chapter 7.

Competing to survive as political experiments

The SOIs in this study are suggestive of political experiments, though to varying degrees by institution/quadrant of innovation. As emerging organizational forms, they are infused with values, money, and people, and they work to protect their interests and goals. Of course, *politics* can connote zero-sum games on campuses of competition for survival. Certainly not all SOIs evince such aggressiveness in or orientation toward defending their territory, faculty members, and resources. Yet across the four institutions many of the SOIs share a common goal to endure.[53] As they all represent, from the perspective of institutional theory, localized sets of values and also have some self-discretion over unit-level planning, the SOIs in this study tend to self-protect to ensure future advancement. Interestingly, too, they are *experimental* organizational forms.

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[53] To be clear, this thesis focuses on the parturition of SOIs that are still alive rather than on the death of these organizational forms. I address this further in Chapter 7.

Their great variety within and across the institutions in this study indicates increasing but *unproven* efforts to advance knowledge and secure resources. We do not know the exact combination of, or calibrated investment in, centers, institutes, schools, and departments to meet competitive goals. Nonetheless, it may help to consider how the cases of SOIs vary in their political, competitive orientations.

At UVa, within the high institutionalization/resource strengthened quadrant, the SOIs largely reflect a network of collaborative, virtual centers and institutes. The SOIs do not necessarily try to outcompete one another for scarce resources, but their parturition suggests the importance of clearly articulated value statements that meet strong normative expectations. SOI administrators work to position and frame their units accordingly. As one SOI administrator said,

> [There's] always a handful of people who sort of vet it, that, of course, [and], in fact, I would even argue that we are all, irrespective of who or what we are or what we do, that we are here to basically…educate ourselves, those around us to understand the world around us, and to do something that would make it better.

Such a perspective suggests an aim of SOIs (and their leaders) at UVa to make an appeal for support based on applying specialized knowledge to improve "the world around us." Yet some SOI administrators have a tougher argument to make than others.

Recall that some SOIs, such as the Applied Research Institute and the National Center for Hypersonic Combined Cycle Propulsion, position to diversify federal R&D funding from defense-related projects. "I was going to say there's a lot of ways it works against you," an SOI administrator said of such a culturally engrained institution. "It's not all just about spies…it's about analytics and thinking…. You hit a nerve sometimes with people, which is funny, because Thomas Jefferson used spies all the time." Indeed, a faculty member discussed the importance of participating in genuine and authentic service and "outreach to the public as opposed to—and I'm not meaning to say this cynically at all, but 'PR work' for [the unit] itself." Value statements suggest claims for legitimacy that can allow units to emerge but also *endure*. Yet to survive the SOIs must continue to claim (and, over time, demonstrate) additional benefits in research, money, and collaboration that UVa "would otherwise not have gotten," an SOI administrator said. For example, the Center for Automata Processing has already captured significant private industry investment, and, over the long term, as stated in a university online news feature, "will bring in researchers from other Virginia universities and companies and leverage additional funding from corporations and state and federal funding agencies, and eventually will expand nationwide" (UVa Today, 2013, p. 2).

Analogous to UVa, UIUC has a well-defined history of prominence in scientific research. While the two institutions overlap in high institutionalization, they differ in their resource positions. From the high institutionalization/resource threatened quadrant, UIUC tends to feature some notable inter-unit competitiveness among SOIs for resources to advance their particular areas of research. Paradoxically, SOIs compete on campus for money, but their independent successes can ultimately reaffirm UIUC's overall prestige in science and institutionalization in the AAU. The formation of the School of Molecular and Cellular Biology (MCB) and the School of Integrative Biology (SIB) provides an example. According to one observer:

> So…about 17, 18 years ago now, many institutions in the United States looked at biology in a different way. And biology, in many places, fissions along the molecular and systematic axis. If you are cynical, you would say this is a money axis, because at the time, the people in systematic biology were basically individuals—I'm not being derogatory, but their idea of research funding was a travel

> grant to go to Panama or wherever and collect samples, and come back, and figure out what they were. And…then the other was, of course, the explosive growth in molecular biology, and these guys are all going out and getting big NIH grants and so on. So there's a difference in the resource base that was funding these. I think that was a big driver.

While the schools represent differently funded areas of research in the life sciences, together they now position UIUC for money for biomedical and also genomics projects. In fact, the Department of Biochemistry was "falling behind" in the School of Chemical Sciences, another respondent noted, but later flourished when it moved to MCB because it received resources proportional to what the department generated in external grants. Thus, in the formation of schools, we see a combination of driving factors, most notably scientific developments in the field, discoveries of individual scientists, and funding incentives from mission agencies.

Institutes and centers on campus pursue slightly different approaches than schools and departments to compete for viability. On the whole they intend to foster collaboration across the various units at UIUC, yet to succeed in their efforts can propel internal competitions among affiliated faculty members and research teams. For example, the Institute for Genomic Biology (IGB) receives a hard-money line from the state and Vice Chancellor for Research, and to sustain itself must win federal R&D funding. It organizes around interdisciplinary themes that codify based on director and peer-approval of faculty research teams and propensity to secure grants. But themes can be dissolved as needed, when, an observed explained, "the animating idea, the moment of that idea may pass, [and] events, larger events may sort of surpass it, and so on the national scene…there are reasons." In the case of the Department of Bioengineering, with wide coverage of agricultural and medical research areas, we may anticipate an inevitable intra-unit shift. The relatively new department will likely position itself further to contribute to—and benefit from—the development of an Engineering-focused medical center on campus. Here UIUC's resource-threatened position seems present in the competitive, political nature and emergence of many SOIs on campus, and resource aspirations are coupled with a collective goal of preventing a fall in institutionalization.

SBU, akin to UVa and UIUC, seeks to build on its early success in federally funded science. Within the low institutionalization/resource threatened quadrant, its SOIs largely form a close network of faculty members and units that leverages capital investments to boost research and competitiveness for federal R&D funding. There, the focus of SOIs was not necessarily to compete with one another for scarce resources, but to build-up legitimacy (e.g., institutionalization) as contenders in disciplines and fields and among mission agencies. In the institution's early years, recall that SBU's second president John Toll aspired to make the university a Berkeley of the East. Interestingly, modern-day comparisons put SBU in mind with University of California at San Diego (UCSD), a comparable institution in size/scale but even stronger than SBU in some programmatic areas. Indeed, UCSD "was an impetus for us to more seriously consider bigger organizational change," a former campus leader said.

Yet SBU's SOIs, intended to give advantage and edge in research, were viewed among some as "experiments." The context of low institutionalization suggests a pocket of latitude (e.g., a relatively small degree of normative barriers) for risk-taking in developing a range of new organizational forms. While each particular SOI was *active* in research, it was not, as an individual entity, necessarily time-tested in its effectiveness. From a resource threatened position, a number of SOIs nonetheless pieced together funds from donors and the institution and were meant to self-sustain on external grants. According to one SOI administrator,

> [O]ur center is a big experiment. It's an experiment in can you float on your own model, which means…yes, the donor put in some startup funds and yes, the university put in some faculty positions. But five years from now, then what? And the "then what" is what's really our purpose, if you like…we're aiming to try to be strong enough among the faculty we have doing just research and much less teaching to be able to bring in grants to support the thing. And so…what's the business model of a university going to be in 20 years? A lot of this is going to be about bringing in outside dollars because the tuition and fees thing is just not going to keep working anymore.
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> So…as an experiment, we have yet to know if our model is going to work. I believe it is. …But this is going to depend. If the NIH or the National Science Foundation get hammered going forward, we could be in trouble because this is not a good time in the landscape out there to be trying to live on federal dollars.

Such a perspective suggests the risks involved, within a context of limited resources, in basing the business models of centers and institutes on external funding. As one faculty member explained, it was important to have "soft money people…whose job it was to write grants to *feed* more people" (emphasis added). But lean operating budgets, to keep costs relatively low, can preclude the expansion of personnel to help secure additional grant funding to sustain SOIs and, in turn, strengthen the status/standing (e.g., institutionalization) of SBU. Indeed, there was a perception that centers and institutes were successful if they captured "programmatic money," an SOI administrator said, or, as others suggested, were able to move research advancements to clinical application.

Apropos to UVa, UIUC, and SBU, UF aims to leverage SOIs to coordinate research to compete for federal R&D funding to advance its status/standing. Within the low institutionalization/resource strengthened quadrant, the SOIs at UF aim to use money to facilitate connections throughout the campus' expansive academic structure. But, even with strong, growing campus resources, emerging organizational units can prompt jealousies—and some rivalries. The Department of Biomedical Engineering, for example, was started primarily from a philanthropic gift but also from college-level resources. Its financing fostered some misperceptions of unit wealth that prompted inter-unit distance rather than collaboration. An observer commented,

> When you start a new department…there's this perception that resources are being diverted to something new…there's a fear that overcomes other people in the same college, like, "Well, there's a certain amount of money that's coming to the college. If we have a new department, we're all losing something because the forming is one thing." So…the first thing that comes to mind is the resources, and people get a little…defensive of their territory and get a little defensive, you know, "What is that going to mean in terms of resources, what is that going to mean in terms of our faculty?"

Such a perspective suggests the need for new SOIs to establish their legitimacy and partnership with other units that may doubt the mutual benefit of linking together.[54] While UF and its SOIs aim to ascend in status/standing (e.g., institutionalization), their allocation of money becomes the way in which to motivate acceptance of new organizational directions and units.

As one SOI administrator said, collaboration that leads to grant funding helps centers and institutes "prove value" because they, as new organizational forms, are "an investment." Indeed, the business model of some centers and institutes sought to divvy

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[54] While the Department of Biomedical Engineering received backlash for its resources, it also had its intellectual status as a discipline challenged. A campus leader explained that disciplines and fields should show that they have "withstood the test of time, and therefore people have been able to question, add to, debate, share, and come to some conclusion." As one faculty member said, departments often have identifiable "core intellectual content" that signals their tradition—and acceptance—in the academy. Nonetheless, the sheer amount of federal R&D and philanthropic funding for biomedical research underscores economic legitimacy though some may still question its academic heritage.

up overhead from grants to entice involvement of departments. One institute, an administrator said, uses its hard-money line for start-up costs and some salary for affiliate faculty, and

> overhead costs are frequently what drive a university, and the way it's set up, the institutes automatically get 7.5% of overhead, which does not interfere with the 10% that departments routinely get. And, so, consequently, for a department chair to collaborate on recruitment [of faculty members], not only do they get a top investigator at a cheap price, they will also get that investigator's overhead return…without my taking anything from it. So they get a top-notch investigator at half price, plus they get the full overhead return. That's really attractive.

Thus, centers and institutes could offer a natural overlap in research agendas and funding opportunities with academic departments, but the potential for lucrative success, rather than normative fit within a highly institutionalized setting, tends to drive their interactions and suggests their rationale for survival.

Serving the medical enterprise

Most SOIs in this study position around the biomedical sciences and, as such, aim to leverage the academic-research core to strengthen the medical enterprise. The SOIs move beyond the integration of academics and medicine, for they suggest a power dynamic by which medicine—and the goal of capturing NIH funding—subsumes all else. Indeed, such a finding indicates susceptibility of SOIs to influences from the *medical profession* rather than emulative pressures, per se, from the field of higher education (e.g., copying the academic-medical research powerhouse Johns Hopkins University). Within this context, the survival of SOIs can come from their links to the research- and funding-opportunities in the medical arena. To demonstrate the relevance of research for human health and societal benefit may mask some market- and money-making interests of SOIs and institutions. But it can affirm status/standing and the legitimacy of organizational pursuits. Here, many of the SOIs compete for NIH money, the richest of mission agencies and the highest funder of R&D at universities. Recall that in Chapter 5, UVa, SBU, and UF have each received its largest share of federal R&D funding from NIH, while UIUC has sought by way of SOIs to make NIH its top sponsor. The degree to which SOIs *serve* medicine varies some across the sampled cases and institutions—a point of distinction that further underscores the nature of their variation.

The SOIs at UVa suggest aims to maintain longstanding commitments to and resource streams from NIH- and NSF-funded areas of research. From its efforts in knowledge production, funded by these mission agencies in particular, UVa has achieved its place within the high institutionalization/resource strengthened quadrant. To support institutional aims, the sampled SOIs tend to focus on biomedicine. While centers and institutes have the capacity to steer the academic core toward the medical enterprise, they do not always have such clear, direct connections. Hospital facilities are maze-like: "I don't think many people know about all the science buildings down in the hospital," an emeritus campus official said. "You'd have to go there deliberately to find them." Yet some SOIs, such as nanoSTAR, demonstrate strong academic-medical affiliations. For instance, nanotechnology could lead to precision in drug delivery and, in other applications, map the human brain and nervous system.[55] Other SOIs at UVa, though not

[55] One SOI administrator commented on President Barack Obama's "new moon" initiative to understand the human brain and nervous system. While such national interest will surely heighten funding for applied research, the respondent noted, it may preclude fundamental research and, in turn, full understanding of human health. "Some people are very excited, because it's so integrative, and you're going to bring together

solely focused on medicine, could leverage their technology and core facilities to research human health and behavior. As another emeritus campus official explained,

> It is the computer that allows you to simulate things that you could not before. Now…say on a lobster claw, I can easily simulate every single neuron and every single connection between neurons—to try to make a theory of what it does. Well, you couldn't have manually done that. You couldn't create a manual physical simulation, but you can do it in the computer. So the computer is actually a tool, just like an electron microscope…that opens up new vistas, and every time a new vista opens up, researchers will pounce on the problems that are now tractable that were not tractable before.

Technological advancements in the research core, which affirm UVa's reputation in science and position for external funding, attracts industry partners whose investments can help move discoveries to application. A consequence perhaps of strong institutionalization in research and resource providers, UVa has overbuilt some laboratories around growth-trends in NIH's budget that has since undergone recent, marked tightening (see Harris, 2014a,b). Thus defense-related SOIs could "enlarge the research pie," as one SOI administrator said. But medicine continues to have strong pull, for its resource-strengths and values. Medicine evinces the needs of "homo sapiens" to ensure "survival," another SOI administrator said. And SOIs that pursue such work within the medical arena can, the respondent added, "be provocative…that's part of the message and its urgency."

SOIs at UIUC aim to foster incremental shifts toward a fundamental, institutional repurposing for NIH money in biomedicine. Recall from Chapter 5 that the combination of high institutionalization and a resource threatened position prompts a fear of falling in

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many disciplines, but the traditional neuroscientist, even biologists think that we're not ready to do this kind of integrative stuff when you don't know the fundamentals. You know, the same thing happened with cancer. They were developing drugs left, right, and center without understanding the mechanism of cancer biology, right?"

status/standing. In this way SOIs at UIUC, though competitive among themselves for money to ensure viability, can help to sustain the institution's national reputation. Analogous to UVa, UIUC emphasizes its efforts in nanotechnology to strengthen its renown for benefits to human health and also to capture research funding at the nexus of engineering technology and medicine. Two centers—the Center for Nanoscale Science and Technology and the NSF I/UCRC for Innovative Instrumentation Technology—work in part to develop sensors for pharmacological screening. The Department of Bioengineering has a somewhat broad range of research areas, with application to agriculture and medicine. Yet a major push was underway in 2014 to develop a stand-alone medical school on campus that deliberately integrated engineering and medicine.

The need for such a transformational development, however, was couched among campus and SOI leaders in normative terms of efforts to best improve medical *education*. While the justification has some face-validity for a public flagship, which teaches a large proportion of students relative to other institution types, it suggests the utilization of students to foster cross-disciplinary collaboration at UIUC among faculty members. An emeritus SOI administrator explained the "gulf" that can exist between engineers and physicians, but

> the concept there is pretty simple. It says, can we create another type of physician of the future that there is no "us and them," so to speak. They're fully integrated within four years of medical school, so they understand medicine, and they understand technology. They can think of the human system as a control system, for example. They can understand that cell networks can be analyzed by looking at network analysis as engineers do.
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> And integrate that, into the practice of medicine with all the high technologies and things that come in, and now all of a sudden you have a physician who says, "Why don't we have this device? I mean, I understand this process. We need this device." And then there's collaboration, and then there's no more gulf between.

By reducing the “gulf” so that engineering strengthens medicine, SOIs may very well enhance the educational reputation of UIUC. Indeed, MCB has in its research and teaching clear connections to medicine, while SIB has research accomplishment but works to codify a “unique identity,” a faculty member said, to appeal to students who want to attend medical school. But such a proposal mainly sounds “sexy,” another emeritus SOI administrator said, because it entails the prospect of boosting NIH funding for research. The potential money-to-come from utilizing engineering for medicine may carry additional poignancy within the resource threatened context.

The SOIs at SBU largely serve to enhance the institution’s early reputation in and resource-generation from biomedical sciences. When the Department of Biomedical Engineering formed in 2000, it pulled faculty members from the medical school. Such a move explains why the department, in about 10 years since its founding, can recruit new faculty members who already have external grant funding. The success in bacteriology in the Center for Infectious Diseases, positioned around national concerns in anthrax and human health, further exemplify the leveraging of centers and institutes for medical status/standing and money. Growing momentum around application of technology to medicine emerged in recent years as well. For instance, common interests in imaging, modeling, and predicting human health outcomes tied the Center for Structural Biology, the Laufer Center for Computational and Quantitative Biology, the Institute for Advanced Computational Science, and the Institute for Chemical Biology and Drug Discovery within a network of resources and faculty members. There, researchers can develop “computer models of various biological systems,” a faculty member said, “and use those either to try to understand more about the fundamental biological mechanisms that regulate their function, or to engineer interventions in them. So, for example, to engineer a new protein…or to change a protein to have an inhibitory effect against some pathogen." Such discoveries—and their clinical application—could thus serve well the institution's aims of improving in institutionalization and resource position.

Interestingly, SBU's President Dr. Samuel Stanley, appointed in 2009, is himself a biomedical scientist by training. He reflects an increasing emphasis on campus to position the academic core to benefit the medical enterprise. According to one campus leader, medical interests can prompt institutional directions that preclude input from shared faculty governance. In other words, the pursuit of biomedical research can supplant, among institutional leaders, consultation with some faculty members about competitive goals. "Physicians think they're gods," the respondent said, as they influence life and death outcomes in their research and, at times, exert entitlement to resources and decision-making authority. Early efforts at SBU to leverage the academic core for medical research has nonetheless helped the low institutionalization/resource threatened campus to raise its status/standing and expand revenues: "You know, even in biology and medicine…you were in your boxes," an emeritus campus official said, "and I see that changing, that bringing together the medical and academic campuses was very, very important to the kind of research that is happening now."

Many SOIs at UF intersect with medicine, and their relevance for biomedical-related research has helped them to develop. These SOIs are also largely responsible for extending UF's resource strengthened position amid institutional aims of advancing status/standing. Both academic departments included in this study, the Department of Biomedical Engineering and the Department of Environmental and Global Health, were founded within the medical arena. They have the potential to enrich research agendas on campus, while adding opportunities for philanthropic and NIH funding.

The primary benefactor to the Department of Biomedical Engineering, Dr. J. Crayton Pruitt, was himself a physician. He and his colleague had invented the Pruitt-Inahara shunt to reduce “the amount of strokes that occurred during carotid artery surgery,” a faculty member said. Dr. Pruitt donated money to endow and form the department as the medical school already had a strong history of receiving philanthropic gifts. By targeting the main academic core, his money had an increasingly visible, impactful effect. The Department of Environmental and Global Health suggests an offshoot of human medicine. Its research foci include water systems, plants, and animals, helping to further understandings of the transfer and treatment of pathogens between people and ecosystems. Legitimacy comes from its relations with, though slight differentiation from, medicine.

Ultimately, though, we can see in SOIs at UF the ascendancy of biomedical research to enrich the medical enterprise. Strong motivation comes from wanting to leverage resources for additional money to enhance institutionalization—belonging—among the academic elite. Centers and institutes in particular could plug into and strengthen an already-research oriented medical school. As one emeritus campus official observed, it has been “over the past generation [that] the large amount of bio-related funding has benefited those institutions with strong medical enterprises.” Such alignments could also help SOIs and the institution compete for NSF funding for fundamental research—even within traditionally applied disciplines and fields such as chemical, materials, and mechanical engineering.

Positioning to co-opt federal funding streams

On the whole, the SOIs in this study provide opportunities for faculty members to gain national visibility in their areas of federally funded research. They offer some potentially prominent ways to certify experts/specialists of importance to national interests. In this way, SOIs position faculty members to interact with mission agencies, sharing their perspectives on which emerging research-areas are worthy of federal money. At the same time, SOIs can affirm the status/standing of individual faculty members based on research accomplishment, and, in turn, faculty members then become likely candidates to serve on review panels. Facilitating exchanges with mission agencies and providing pathways to participate in peer review, SOIs fall somewhere between enabling co-optation and control (vis-à-vis resource dependence). SOIs do not let faculty members dictate national funding priorities, but, in this thesis, seem to provide a *platform for influence*. From the resource-dependence perspective, SOIs do not *cause* the taking over of peer-review, though may facilitate faculty members' involvement in committees that determine funding allocations.[56] Across cases, SOIs vary in degrees of responsiveness and also in the amount of external influence they seek to enact.

Recall that at UVa, centers and institutes aim to provide a "conduit," an SOI administrator said, between faculty members and external stakeholders. The high institutionalization/resource strengthened context in which SOIs emerge at UVa can foster external perceptions of their legitimacy. As they become conduits, the SOIs centralize communication of funding opportunities to faculty members, but can also

[56] Some institutions may be more likely than others to have formal influence over federal R&D funding priorities, with historically strong levels of involvement among the most academic elite (see, for instance, Slaughter, 1993a).

match prospective industry partners, for instance, with faculty members based on research areas of interest. A key component of serving as “conduit” entails the positioning of faculty members to work closely with mission agencies. They can provide an opportunity to visit with program managers and contribute to conversations about emerging project areas to fund. In addition to advantages in leveraging its high institutionalization/resource strengthened position for external relationships, UVa’s close proximity to Washington, D.C. also helps SOIs and faculty members access mission agencies. As two SOI administrators each observe:

> [We] make routine trips to Washington and go knock on doors and see what's going on up there, you know? What's DARPA doing now? What's DARPA worried about in the next 10 years? …that's a high risk, high reward environment…[so] what are they willing to invest in?
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> In fact, the last few days I was just at NIH, and we had a two day workshop that I helped organize on aging and place, and we had everyone from Medicare to… vendors, to patients, to all the technical people coming together to say – they call it the “silver tsunami.” All the people are aging at a hurricane rate, and how are we going to deal with this? …So that's not a new vision, but the ideas, they're starting to pay attention and things are happening enough that the technology is being considered, that it can help, and so we just had this two day meeting….

Such perspectives suggest initiatives, especially among SOI administrators, to shape federal funding priorities to increase the likelihood of SOIs and faculty members receiving grants. They do not mean that federal mission agencies will always follow the recommendations, but rather that the scientific community has to be involved in identifying what lies ahead in disciplines and fields.

While SOIs provide access to mission agencies, their main benefit pertains to strengthening the credentials of investigators to make them increasingly reputable/competitive for grants. One faculty member discussed seeking funding for a project for which the respondent was not necessarily a demonstrated expert:

> …reviewers and [the program manager] said, "This is a really good idea. You are not qualified to do it. You just don't know what you're doing." So I called [the program manager] up and said, "Okay, you're right. I buy that. Who should I get to work with?" And [the program manager] mentioned the name of a faculty member who was coming to another part of my university in the fall and had this conversation with [the colleague] in the spring. I immediately hooked up with that person and [we] submitted another proposal and [the colleague] was a world-class expert on [the topic]…And then we were able to get that one funded.

The communication between the faculty member and mission agency led toward a federally funded project. Clearly such a cross-campus collaboration does not always originate in centers and institutes; a colleague may reach-out to another without the help or support of particular organizational units. But at UVa the SOIs and their administrators aim to heighten interactions between faculty and funders—and faculty and faculty. It helps people to identify experts with fundability, and success in securing external resources may further reinforce an overall high institutionalization/resource strengthened position.

At UIUC, numerous SOIs largely compete to improve their own prestige and resources. Many fall within a somewhat loose network of units on campus through which occurs the exchange of research, money, and people. Though mostly by way of independent initiatives, the SOIs also aim to uphold the institution's reputation (e.g., high institutionalization) for scientific eminence. In contrast to UVa, UIUC's resource threatened position may intensify inter-unit competition, and its Midwestern location precludes easy travel to mission agencies. As one campus leader explained, the goal was "infiltration" to shape funding priorities to increase chances of winning federal grants:

> Typically a lot of our faculty are either involved in organizing workshops or… brainstorming sessions in their fields. NSF runs a lot of workshops, the forum calls, the Department of Defense…Department of Energy, they have workshops around sort of new and emerging fields, so you like to have your faculty participate in those to sort of get in on the ground floor. Some schools do a better job of that than others as far as getting their faculty in those meetings versus into meetings…it's one of those things where if you're in that first meeting…you can have a very big influence on what the call looks like at the end of the day, right? So…it's not a generous word, but "infiltration" is really essentially what it amounts to, right? Some schools are much better at that than others. There's a perception that because we're in the middle of the country or not on either of the coasts we're not as good at that as some of our peers. I tend to agree. Also, sometimes our faculty, if they don't feel like they're going to lead something they might not necessarily volunteer for those to go to those as much as maybe some of our competitors on the coasts, I don't know.

Such a perspective indicates a motivation to influence—*infiltrate*—the direction of federally funded science toward areas of strength at UIUC and among its faculty members. By exerting such strong influence on funding proposals, and the outcomes/outlays of financial decisions, the SOIs at UIUC could thus prevent falling in institutionalization of scientific status/standing.

SOIs do not necessarily *cause* success in these co-optation-like efforts, but the prestige of organizational units can increase the likelihood of faculty members receiving grants. Some SOI administrators doubted whether academic structure led to national prominence and increases in grant funding, or whether it came from the quality of faculty members, the rigor of their work, and the access to resources and technologies to make scientific advancements. Yet according to one faculty member:

> And our perceived standing matters to us, not because of ego. It matters to you when your grants go up to a study section at NIH, and they…recognize that you're in a department that is highly regarded, you know, it bleeds off some happy thoughts, alright? And it helps you, and we don't want to lose that, okay? That's the deal.

SOIs can thus generate reputational advantages that affirm the credentials and expertise of investigators. In turn, SOIs could help make faculty members increasingly competitive in the peer-review process for federal R&D funding.

The SOIs at SBU strive to increase the research-funding base to improve the campus' low institutionalization/resource threatened position. Though the institution has seen early and some ongoing success in federal R&D funding, its SOIs suggest heightening sensitivity to fluctuations in mission-agency budgets. A segment from an interview with an SOI administrator provides a telling example:

> JW: What is it like to piece together continuity of funding to get the research and discoveries to that [application] phase?
>
> SOI Administrator: There's no answer that I would possibly put on tape for that because it would be something that would not be…suitable for a young audience to hear. I mean "continuity" and "funding" are two words that do not belong in the same sentence. I mean, it is a Sisyphean daily battle. I mean, if we're going to talk about Sisyphus, call it Dante in the Inferno. Do you know how many rings there are in the Inferno? What are there, nine? I mean, most of them are filled with academics looking for funding. I mean, it's just brutal.

Analogous to such a perspective of resource-competition, one department chair wished for "Harvard's problems" of what the respondent perceived as having too much money. At the same time, SOIs offer the access to facilities, equipment, and collaborators to produce strong science; research discoveries could thus help faculty members gain the attention of mission agencies to promising areas of research. According to one faculty member:

> I think…one of the only ways that researchers can *control* how the NIH spends money is just by making discoveries in areas, and then those areas become major areas of interest and the NIH starts funding them, you know? Look at examples of basic research

> discoveries that have ballooned into large areas of research that the NIH has funneled money into over the years.
>
> …research is always pushing forward the envelope and then based on those discoveries and the applications of those discoveries, the NIH is just behind the envelope…just behind that cutting edge, and they do go through different phases that they spend a lot of their money on and that's partly driven by Congress and partly by the administration of the NIH…the administrators, the directors of each institute, what they want to spend their money on. (Emphasis added)

Yet, analogous to SOIs at UIUC, prestige at the unit-level could position faculty members for research achievement and additional funding opportunities. The involvement of faculty members in review panels underscores the prominence that can come from research specialization and affiliation with reputable SOIs and institutions. A faculty member explained:

> …I've served on, you know, study sections. We have panels and things like that, and if the panel recognizes the person, [the] investigator who's grant they reviewed, that person immediately gets a leg up. If it's an unknown person coming in, then…they're looked at much more skeptically I would say. You know, if you don't have a track record, if you don't have some prestige, if you don't have name recognition, it definitely hurts. And that's separate from the…merit of the science. So…it's very important to build that prestige. So it helps to come from a prestigious university, a recognized university.

Such a perspective suggests the relationship between status/standing and resources: to improve the legitimacy of SOIs and the institution can hold sway in peer decisions to allocate limited federal R&D funding. In competition for DOE money, partnership between the Institute for Advanced Computational Science and the Brookhaven National Laboratory could likely raise the scientific profile and technological savvy of investigators for grants.[57]

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[57] An observer mentioned the importance of technology at Brookhaven National Laboratory that, when combined with computing capacity at SBU, could strengthen

UF seeks to utilize SOIs as part of broad efforts to recruit preeminent and eminent faculty. Through targeted hiring, the Preeminence Plan suggests, UF can elevate its status/standing among elite public and private universities. Preeminent and eminent faculty members tend to have strong track records of external research funding, making them important to institutional competitions for resources. At the same time, research stars receive opportunities to work with mission agencies to establish funding priorities; they are at the forefront of their disciplines and fields. An SOI administrator discussed the leverage of SOIs and state-funded salaries in recruitment of preeminent and eminent scientists:

> They want the latitude, the ability to know that the salary is covered, that they're not constantly struggling to make sure they can cover their salary. It gives them the freedom to look at new ideas. And, again, then you place them into an interdisciplinary institute such as this [one], they're here with…faculty from a lot of different places, with other preeminent scholars. That's an attractive setting.

Such a perspective suggests the importance of money and latitude, which centers and institutes can provide. Money matters, and for a resource strengthened campus, UF needs additional state-backing of salaries to outbid financial offers and start-up packages from elite private institutions. In terms of professional latitude, SOIs foster boundary-spanning on campus and between campus and external agencies. A campus leader discussed the importance of having "quality faculty, faculty that are at the cutting edge…people that are very visible on the national scene [as] recognized, technical leaders." SOIs help to

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research efforts. "So there's a billion dollar x-ray source up at Brookhaven, and that produces a lot of data," the respondent said, "but you've got all these images, what do those images mean? …You have to do an enormous amount of computing based on a lot of rigorous theory and math to make get that information out. " The ability to handle big data, then, provides a distinct area of specialization and potentially lucrative niche in competition for external funding.

attract them, the respondent added, as they purposefully encourage research within fluid disciplinary boundaries.

The SOIs, then, aim to anchor the research efforts of top, nationally recognized researchers who further shape the direction of external funding streams. One SOI administrator had recently visited NIH to present early findings potentially useful in biodefense. "If I tell you any more, I'd have to shoot you," the respondent quipped. With NIH in particular it has been increasingly important to stabilize funding for individual and center-level projects. Budget fluctuations at NIH and other agencies prompt uncertainty: they alter in unpredictable ways the target-areas and funding levels for current and future projects and thus changes the likelihood of capturing grants. To have influence in forward directions of federally funded science can provide strong, strategic advantage—especially to UF's efforts to deepen its institutionalization among the academic elite. A faculty member explained:

> And NIH, they had kind of an interruption last year, and a lot of people that were getting sort of persistent funding ended up not getting funded. And then that creates a lot of problems. I think…there's a lot of uncertainty, too, in funding because, you know, it's always political, and it fluctuates all the time, and a lot of agencies have moved towards more of this large center type model. Which for good or for bad, I don't know. But so you've got to really be…you've got to be participating in that game….

Forming centers and institutes can help to capture federal R&D funding based on how some mission agencies award their money (e.g., by investigator, team, center, etc.). But centers and institutes also position to get ahead "in that game" of anticipating, of shaping, where the money for research will go next. In this way, the resource-strengthened position of UF suggests a striving for even more money to position SOIs to recruit the faculty members who will help the campus ascend in status/standing.

Strengthening prestige-claims among the academic elite

The campus leaders, SOI administrators, and faculty members across the cases and institutions in this study can largely be described as *opportunistic*. They share common ambitions to raise their national profiles (e.g., institutionalization among the elite) and resource positions, and they continue to push and experiment with organizational forms to pursue strategic advantages. In their accounts of leveraging SOIs to meet competitive goals, we hear some divergence among the respondents. Campus leaders often emphasize the importance of SOIs for status/standing in the AAU. As AAU member presidents consider new, potential inductees, they tend to look closely at universities' profiles of centers and institutes as such organizational units channel federal R&D funding and heighten the visibility of research-activity on campuses.[58] SOI administrators and faculty members value institutional prestige; it benefits them in faculty recruitment and in panel reviews for grant funding. But their focus, as suspected, entails prestige according to peers in disciplines and fields. On the whole, the utilization of SOIs for institutional recognition and reward in the AAU suggests the importance of

[58] In 1988, AAU member presidents were considering new, potential institutions to invite to join. That year, University of Arizona President Henry Koffler wrote to UF President Marshall M. Criser, among others, to share information on one institutional candidate, University at Buffalo—State University of New York. The Koffler letter included, under the heading "Selected Centers of Excellence at the State University of New York at Buffalo that Contribute to Research Programs at Other Major Research Universities and Major U.S. Corporations," a five-page list of 19 national research centers and institutes. Indeed, in 1989, SUNY Buffalo was invited to join the AAU, and, as Koffler's letter suggests, centers and institutes seemed to facilitate a network of research, people, and funding that brought about and would certify elite status and standing and prestige. See: Henry Koffler to Marshall M. Criser, December 29, 1988, Administrative Policy Records of the University of Florida Office of the President (Marshall M. Criser, Jr.), Box 7, Special and Area Studies Collections, George A. Smathers Libraries, University of Florida, Gainesville, Florida.
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academic structure among the elite. Campus leaders current and emeriti are quick to highlight the lack of control they have over faculty members, though they can incentivize them by way of budgetary allocations. Not all campus leaders approached strategic change with sensitivity to the AAU, differentiating the extent to which the institutions in this study integrate cues about change and adaptation from their field-environment.

The SOIs at UVa have developed within an institutional context of deeply embedded status/standing and resource-strength. Yet not many interview respondents discussed the AAU directly. Such a finding suggests not so much a presumptuousness or entitlement of the elite but rather an engrained, embedded aspect of life there. UVa has, in essence, always been in the AAU and continues to innovate because it can and is expected to remain competitive. A segment from an interview with a campus official offers an example:

> JW: I know as part of the Cornerstone Plan, the institution is looking to make it into the top 10 in reputation nationally, and I just wonder, in your mind… what will it take [for] a place like UVa to be able to reach that, to be able to go up against some of those elite and particularly private institutions also in the AAU?
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> Campus Official: You know, I think one of the things that we have going for us is that we have a lot of areas of existing strength, and so one thing you have to do is to keep up your current areas of strength. …So I think that we've got, you know, some very good elements in place to build with. We don't have a ton of money that a place like Harvard has, but, you know, the smaller size actually in some ways gives us advantages Harvard doesn't have.

The predominant perspective at UVa suggests innovation from "existing strength," but also a lack of "money" in comparison to competitors such as Harvard. UVa is not necessarily resource-threatened, and if not attributed to financial constraint, the strong normative environment may thus guide organizational change and adaptation toward traditional "current areas of strength." SOIs, then, tend to reflect efforts to stay cutting-edge in the scientific community that affirms UVa's position of prominence. As one SOI administrator explained,

> I think that when you are a top research university, top 50, top 100…you have researchers who are trying to stay on the cutting edge. They see what their peers are doing, and they realize that there are a lot of benefits and a lot of opportunities when you create centers or create spin off companies, and that's just part of the air now….

Another SOI administrator described the "prestige" of having centers and institutes because it "allows you to publish papers in a certain area or certain time. That helps your credibility…but [for] all the benefits and all the talent, funding is never easy."

UIUC, analogous to UVa, has been an AAU member nearly since the beginning of the field's formation. Its entry date of 1908 has been an indicator of high institutionalization. Academic structure alone is not the sole determinant of UIUC's entrance into the AAU or current status/standing. Over the years, SOIs have nonetheless helped to certify the institution's positioning.

In 1911, three years after UIUC joined the AAU, then-President Edmund James was invited to deliver a talk at the annual meeting of elites. The topic was "The Organization of University Departments – the System of a Single Head, the Harvard System of a Departmental Committee under a Chairman, etc.," suggesting an emphasis on best approaches to structuring and governing the academic enterprise.[59] Recent campus leaders reflect continued efforts to develop the research core on par with AAU

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[59] Letter from Harvard University secretary Clarence C. Little to UIUC President Edmund J. James. See Clarence C. Little to Edmund J. James, May 23, 1911, James General Correspondence File, 1904-1919; Record Series 2/5/3, Box 18, University of Illinois Archives. Interestingly, as Little wrote, "The Association appreciates greatly the interest that Illinois has taken in preparing papers…," indicating UIUC's active involvement in the elite field of institutions.

peers. One emeritus campus official explained that "Illinois was one of the first universities to become a member of AAU" and already had a "highly developed research program" in STEM, but "structural changes were fast" to develop and resulted in centers and institutes, such as the Beckman Institute for Advanced Science and Technology and the National Center for Supercomputing Applications, of high-impact. Perhaps as sign of elite institutional status, and mechanism to shape the elite field, UIUC President Dr. Stanley Ikenberry in 1993 served as the vice-chair of the AAU membership committee.[60] The committee had direct oversight of identifying new member institutions. Within a contemporary context, a current campus leader described initiatives to build-up centers and institutes in particular to "sell" funding agencies on "your idea" for research and also promote the scientific prominence of faculty members.

From the early ambitions of SBU, under its second president, John Toll, the institution has sought national prominence by way of research and graduate education. Its SOIs have supported efforts to become a Berkeley of the East. Interestingly, Dr. Toll's successor, Dr. Jack Marburger, seemed to assume that SBU's rapid ascendancy qualified it for AAU membership. An emeritus SUNY system official remembered that President Marburger had made a "profound error," for "you don't get what you deserve, you get what you negotiate." In this way, President Shirley Kenney, SBU's fourth president, wrote to the AAU and sought the institution's inclusion. An observer recalled how "AAU was enormously important to Stony Brook and to any institution. You know, we were a very nouveau university, and it was our goal until we got there and I think

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[60] Association of American Universities, Annual Meeting Program Booklet, October 18, 1993, Indianapolis, Indiana, Ikenberry General Correspondence File, 1979-2000; Record Series 2/14/1, Box 299, University of Illinois Archives.

rightfully so." While SBU had been considered a potential member as early as 1993, it was invited to join in 2001 when the membership committee scale-adjusted metrics for institutional performance and reputation. For its small size, SBU produced.

The development of SOIs, especially the four that formed around 2000 (one year before induction in the AAU), suggests SBU's aims of national prominence. But faculty members who start centers and institutes do not necessarily factor into their considerations the AAU. "From my side," an SOI administrator said, "I'm oblivious to it. …I would say, and it may be a reflection of being part of the AAU, that over the past 15 years, the campus has improved tremendously in terms of the quality of the students, in terms of the number of students, in terms of the physical plant, in terms of the resources. How much of that is attributed to the AAU and how much of that is attributed to state priorities, I have no idea." A faculty member said that joining the AAU "did certainly raise the profile of the university a little bit," but also noted that research had always been an area of strong emphasis on campus.

UF has been an AAU member for 30 years, joining on July 2, 1985, but reflects a lower degree of institutionalization in the elite field as compared to other public and private universities.[61] Its relative youthfulness in the AAU may suggest aims to conform to peers, and in some ways UF has homogenized by way of SOIs that integrate academic and medical enterprises. In fact, upon announcement of UF's joining the AAU, the university president at the time, Marshall M. Criser, received numerous letters of

[61] See Robert M. Rosenzweig to Marshall M. Criser, July 2, 1985, Administrative Policy Records of the University of Florida Office of the President (Marshall M. Criser, Jr.), Box 8, Special and Area Studies Collections, George A. Smathers Libraries, University of Florida, Gainesville, Florida.

congratulations from federal and state elected officials. The institution was celebrated for belonging, for being like other members.

Yet—perhaps because of strong resources—some campus leaders evince skepticism about the AAU. In 1999, UF President John Lombardi suggested needs to protect institutional interests when they did not necessarily align with AAU's. In his e-mail to senior staff about the possibility of joining AAU members in Washington, D.C. to lobby a Congressman, he wrote: "Unless we are sure we have something directly and specifically to gain, I don't think being clubby w/ AAU presidents is worth our time or energy."[62] A campus leader described the broad indications, from AAU, about best practices for structural and operational advancements:

> The AAU doesn't set down rules of operation of the institution. It puts down metrics that say our institutions look like X, Y and Z and therefore, to be a member of the group, you've kind of got to look like X, Y and Z. You've got to have PhD programs, you've got to have a certain amount of research activity and so forth and so on, so that the group is more likely to have common needs. That said, it's a very eclectic group of universities because of history. They're not all alike at all. They're not alike at all. And so they have a very challenging agenda to keep, that most of what they say and do is in the best interest of the whole group. So that modulates it down to not very strict decision making, you see what I'm saying? It's more communism than a dictatorship. And so I don't find any conflict with most of what the AAU does. …Most of the time, the things they're asking me to support are in our best interest because they are broad enough and broadly defined enough that we fit.

While the AAU can meet broad needs of members in advocating for federal R&D budgets, it does engender some dismissiveness about its influence. According to one

[62] John V. Lombardi to Randy Moore and Betty Capaldi, March 17, 1999, Administrative Policy Records of the University of Florida Office of the President (John V. Lombardi), Box 41, Special and Area Studies Collections, George A. Smathers Libraries, University of Florida, Gainesville, Florida.

emeritus campus official, the AAU "is stupid" and "a snob club," and "there's a small group of people in higher ed who talk to each other about all this. The rest of the world could care less." Such perspectives notwithstanding, UF's SOIs do largely conform to overall trends among elite institutions in structuring for prestige and resources. A department chair commented that a primary goal under the respondent's leadership is to enhance the prestige of the unit.

Privileging access to administrative/financial authority

SOIs across the four institutions vary some in their role in strategies to enhance institutionalization and resource position. When they contribute to such efforts, SOIs may be increasingly susceptible to administrative oversight of campus leaders. Such an image of institutional leadership resonates with a core tenant of academic capitalism: increasing managerial capacity to move organizational units and people toward competition for external sources of money and profitmaking in markets. But SOIs in this study problematize delineation of administrators and faculty members. Here, campus leaders and faculty members may collapse boundaries as they blend resources to seed-fund research projects and, for instance, centers and institutes. Yet SOIs themselves suggest increasing organizational opportunities for faculty members to become administrative leaders with symbolic and financial authority. We can see this in the number of joint and affiliate appointments, reflective of matrix-like organizational structures, whereby administrative leaders are researchers in their own, and in affiliated, SOIs on their respective campuses. The pathway of faculty members into administrative/financial authority varies some across SOIs and institutions, and this variation indicates some distinct milieus/reward systems as rooted within the quadrants of innovation.

At UVa, to carry academic integrity within a high institutionalization environment, SOIs often started from the initiative of faculty members. A clear impetus for becoming an administrator, with access to additional resources and symbolic advancement in status/standing, came from the drive to push forward a related research agenda. As one SOI administrator explained, a center can (in theory) pull in resources not otherwise gained and open the possibility of scientific advancements in high-cost areas of research. Despite fluctuation in their funding levels, especially from mission-agency sponsors, centers and institutes, the respondent added, could still help support research "essentials, the essentials of numerical modeling, theoretical modeling, and experiment." An emeritus campus leader explained how "creating a center or institute is like starting a small company. The people—the entrepreneurs are the marketers. They are the vision people. They are the first tier researchers who are doing the work." Relatedly, an SOI administrator said that a motivation for taking on leadership was "repurposing the brand" of both the center or institute and also the core research program. The respondent later added:

> So you're not the only one asking for the dollars, so you have to show [value], and whoever gets up a center or an institute or whatever, better know something about business, better know something about writing business plans, which you can't do it anymore with just gee-whiz science or gee-whiz engineering. You'd better be able to document that you're going to return something, [of] value to your clients.

Recall that UVa has a tightly defined, longstanding normative environment in which SOIs must fit in order to emerge and endure. While SOI administrators and faculty members may seek to position their units for resources to affirm relevance and justify ongoing support, they also articulate strong value statements about the need for their SOIs in light of mission and purpose. For instance, an SOI administrator explained the explicit educational benefits to students that can come from cross-disciplinary training and mentorship. Situating the SOI's work within the context of UVa's commitment to student experiences resonated with the SOI's administrative leadership, and it opened relationships with other colleagues potentially for external funding opportunities: "[T]hrough the students I think they were important instruments of building foundations of strong collaborations." Convergence of professional and communal interests underscores the transition for some faculty members into leadership positions. One SOI administrator commented on how there are personal benefits to research programs from technological advancements available in centers and institutes, but, at UVa, balance is needed. The respondent elaborated, "So do we live in a community? Do we live in an institution or are we just a bunch of random free agents, billiard balls…crashing across the galaxy? So that was our beginning point."

For such a large institution, UIUC tends to rely on *mid-level* academic leaders and administrators to prompt organizational change and adaptation. According to one emeritus campus official:

> It's not something that could be driven from the top down. Nor is it something that can be driven from the grassroots up. It needs to be driven—it needs to be led from somebody who is kind of in the middle, and who has great leadership capacity, great vision, is a future thinker, out of the box thinker, but also a person who is close enough to the ground to be an authentic scientist, an authentic academic.

The research accomplishment of faculty members gives them legitimacy, and as administrators and leaders of SOIs they can utilize their status/standing as scientific experts to foster collaborations that generate resources. Analogous to faculty members at UVa, those at UIUC seek to lead SOIs to advance research programs. Yet some accounts suggest an opportunity to help a new unit within an emerging discipline and field become institutionalized by building its "identity," an SOI administrator said.

SOIs at UIUC, even the highly adaptive virtual centers and institutes, aim to endure. While some faculty members take on administrative leadership roles, they often seek to balance running SOIs and maintaining strong research. The institutional focus on SOI administrators and leaders as catalysts of change and adaptation has an inherent limitation. Though promising in terms of the access to money, some leaders return to traditional faculty positions. As one emeritus departmental leader explained:

> Every department head, every administrator has to be thoroughly reviewed on a five year cycle, and that's how some people who needed to be moved out, who had been sitting in these chairs for a long, long time, were encouraged strongly to step down. And so for me…the reasons really had to do with how I felt about my research. It was going to die if I did another five years. It was just taking too much time, and I was neglecting the research program, and I didn't want to do that. I just couldn't see that. I became a scientist for the love of science, and so I decided, okay, I'm going to step down after five years. I just told them, "Don't do the review. Just spend your energy hiring somebody else." I'm really glad I did. Those last years were just great years scientifically.

The faculty members who decide to run centers and institutes, because of opportunities to advance in their own work and gain disproportionate financial authority, can bring about the decline of their SOIs. As one respondent noted, a "pure academic" and independent scholar often conflicts with "corporate type level of understanding [of] budgets and money and people and schedules and time lines."

SBU has, for such a young institution, a history of utilizing SOIs to attract and retain star scientists. In 1966, President John Toll recruited Nobel Prize-winner and physicist Chen-Ning Yang from Princeton University. Dr. Yang came to SBU to start and run the C.N. Yang Institute for Theoretical Physics, where he remained for 34 years until his retirement in 1999. Analogously, in recent years, centers and institutes continue to inspire loyalty of faculty members and move some into administrative leadership. For instance, as faculty members gain national visibility for being at the forefront of newly emerging disciplines and fields, they receive offers from other institutions. But an opportunity to run an institute or center can keep them long-term at SBU.[63]

While the institution may be resource threatened, it features somewhat distinct networks to build-out research programs. As one SOI administrator explained, to run an institute or center provides openings to "collaborations between [your] department and some other departments" such as chemistry, biochemistry, cell biology, microbiology, molecular genetics, biophysics, physiology, and pharmacology. It also opens connections and joint appointments with SBU's medical center and partnership with the Brookhaven National Laboratory.[64]

Perhaps indicative of SBU's resource threatened position, a number of SOI administrators and leaders have considered, before accepting their appointments, the financial solvency of their new units. According to respondents,

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[63] An SOI administrator explained being "kind of courted by some other institutions." The respondent "talked to the president and provost and the vice president of research…and they asked me that what did I want to do? I said it's a good idea to really, you know, to make [my research area] into a kind of a center…."

[64] According to one faculty member, centers and institutes can help established investigators build credibility in new, emerging areas for funding, but also allow for collaborations with people who may already have the necessary expertise to satisfy panel reviewers. To compete for funding, the respondent explained, "[I]f you were to change completely what you do, you have to then build up credibility in that new area…you may have expertise in part of it but you're never going to be credible for that unless you can either demonstrate that you now have acquired this new expertise or you bring in someone, you know, [to] collaborate."

> So we actually kind of in a permanent way have some dollars that are always going to be attached to the center. So this center kind of intrinsically doesn't die just if a grant or a person leaves or what have you. And so to me, it had a lot of great built-in stuff, in addition to the academics and the people here and so forth. It just kind of turned out to be an ideal thing from my point of view. (SOI administrator)

> So there was the intellectual draw of this is exactly what I'm doing in my own research, so if I can create it there, then I'll be surrounded by people who have very similar interests and that'll be great for me as a scientist. And the other [reason] was the challenge. This was an incredibly well funded, uniquely well-funded institution in the American academia, almost unique in American academia. It seemed like the opportunities to do something of the highest quality – there were more opportunities here to do something of the highest quality than you could imagine anywhere else. So it was a challenge. (SOI administrator)

Such perspectives suggest the financial lure of SOIs with permanently endowed, continuous resource-bases. Though the SOIs aim to sustain themselves largely through external grants, their risk for survival lessens when they can draw on other resources. At the same time, access to strong resources creates a "challenge" to utilize the money well to advance research "of the highest quality" (e.g., to strengthen institutionalization). As another SOI administrator mentioned, endowed gifts do not solve all financial problems of centers and institutes, but give leverage in "social engineering" and "negotiation" to entice involvement of department chairs and faculty members on campus. When an SOI has money, it can generate additional research but also political support of colleagues and other administrators. It provides a platform by which SOI administrators, with financial authority, can shape social relations on campus.

The SOIs at UF tend to have as administrators and leaders ambitious faculty members. Such a phenomenon seems to resonate well with UF's overall aim of ascendancy. For these faculty members, especially those who seek center or institute leadership, they stand to benefit from new, additional sources of grant funding and also research equipment/facilities. In some ways the decision to start a center or institute has roots in the daily experiences of faculty members. According to one SOI administrator, the initiative to find opportunities to build-up research programs is "like any faculty member, you're on your own. It's up to you to get the funding, and yeah, it's like a small business, right? You just have to make sure that you do the right thing for your area, and you have to be proactive and do it, you know? …You just have to look out for yourself basically." A faculty member considered a leadership position because "the thing is that if you want to survive in this area, first you have to be self-sufficient. And the reason I'm considering it," the respondent added, "is because we've put together a large proposal for the National Institutes of Health, and…I'm thinking that it will give me some credibility to show that I can manage big teams and take on leadership roles."

But a number of faculty members warn of limitations of the awarding of SOI leadership based solely on research accomplishment. One faculty member noted that under a leader who shares resources and information, seeking to incentivize and foster collaborative relationships, a center or institute likely thrives, but under a leader who guards resources and information to serve individual purposes the center or institute fails. Within a politicized campus environment, the personality of leaders matters. According to another faculty member:

> It's that personality of the leader who's capable of bringing people together, and [the director] worked very hard to bring people together, and faculty are hard to bring together. …The centers with the facilities bring 'em together. And you have problems, right? You got to have a director who knows how to be like a duck, right, let the water run off your back, address the problem but you don't put in stupid rules that, let me tell you, university administrations tend…I can tell you they don't think straight.

Such a perspective suggests involvement of faculty members in centers and institutes tends to hinge on interpersonal dynamics, access to facilities and colleagues, and latitude to pursue research. To make sure that SOIs balance benefits across faculty members and leaders, campus officials are typically selective in their allocation of money toward new organizational units:

> I look at broad applicability, I really do. I look at who it's going to impact, and if it's going to impact a very small subset of folks, it's harder for me to get enthusiastic about it. So I look at...are we truly unique there nationally? I mean, if it's an area where it might be a niche field but there's just nobody else in the world doing it, then I'm going to get behind it because this is somewhere where we can have an impact. Or is it something that's going to have broader impact for our [department or college]? So I'm looking at sort of at the area and positioning where are we relative to others.

Recall that, analogous to perspectives at UIUC, campus officials at UF also evince aims of encouraging faculty "grassroots" efforts, a leader said, and "administration level looking over the landscape of expertise and saying, 'You know, where should we form some institutes?" In this way, campus leaders could temper some the ambitious but less collaborative faculty member from privileged access to administrative/financial leadership.

Mediating the ascendancy of academic capitalism

The emergence of SOIs across the four institutions in this study could suggest the continued rise of academic capitalism. Centers and institutes, for instance, may be interpreted as boundary-spanning, interstitial units formed at interstices of disciplinary fields and organizations. Positioned as such, they can forge research-partnerships with industry partners, open new circuits of knowledge (e.g., networks of exchange), serve as platforms for competition for external money, and seek to generate profits from intellectual property. Because of their research agendas, schools and departments may serve purposes analogous to those of centers and institutes. They, too, channel federal R&D resources, providing the financial basis for exchange-relationships with external stakeholders for money-making from patents, licenses, and technology transfers. SOIs in this study, however, suggest an uneven manifestation of academic capitalism. Some collapse boundaries between academe and industry, for instance, but not necessarily to increase shares of institutional wealth. Universities lose money on research, and SOIs may exhibit aspects of academic capitalism in their aims to piece together continuity of resources to sustain high-cost research programs. The SOIs do not necessarily do whatever they can for money: recall that a number of them evince strong value sets to guard self-interest and autonomy. Across SOIs in this study, we can see some variation in degree to which they embody—embrace and extend—academic-capitalist mentalities and agendas.

On the whole, SOIs at UVa can leverage the high institutionalization/resource strengthened position to open additional funding opportunities for research. Perspectives suggest strong needs for money, despite the institution's wealth, as STEM research has such high monetary costs. Recall that a campus official described spending $1.17 of institutional money for every $1 of an external grant that is executed. One SOI administrator discussed why costs were so high:

> The personnel is by far the biggest cost. Even though we don't have to pay the graduate students, we have a research scientist who is full-time, and we have three faculty members, so the personnel is by far the biggest cost. Running the facility is relatively inexpensive. The overhead rate pays for the electricity and what we have to buy…that we need in an experiment. But all of that is relatively small, you

> know, compared to the personnel. Personnel costs are probably two-thirds.

A faculty member articulates the theme well, saying how "academia does allow you to have the choice to do things" and funding helps to "feed" researchers and their work.

Certainly faculty members do not cede complete autonomy to align with mission agencies and industry sponsors, yet shape and motivate their work to compete. One SOI administrator describes the tailoring of research proposals relative to NIH and NSF interests. The respondent explained:

> So, for example, if I was submitting a proposal…I would emphasize the algorithm, the novelty, and then I would say in order to evaluate this algorithm, I'm going to try it on, you know, some…real this or that, and I'll test it, and I'll compare this to that. So the testing part is more of the mechanism for evaluation of the algorithm, okay? Now if I'm sending it to a program that has been created specifically for multidisciplinary, then it has to be written that here is the medical part, here is the technology part. Here is the intersection. Here's why we need this interaction, why I can't do it over here, and so on. And if I'm sending it to NIH, then I'm writing it as, here's the medical problem, and the medical problem has to be solved, or here's a pilot study, and by the way, we're using this technology.

Still, consider the Center for Automata Processing: it formed based on seed funding from nanoSTAR and heavy investment from the company Micron. Industry money in particular helps to buy and develop the core technology for the Center to leverage to build multi-institution and further industry partnerships. It can also be used to fund graduate students (UVa Today, 2013). Core facilities are especially attractive to industry partners whose investment in research fills some gaps in that which federal R&D grants do not cover. As one SOI administrator explained,

> [W]e have, of course, state of the art facilities and resources to try out experiments that industry cannot try out. When I say "cannot," I mean, one is they don't have the facilities, second is the costs at which we would do them are going to be a fraction of what they do with industry. The risks we will take are going to be greater, so they

> can invest…in 10 projects or maybe even 100 projects, and even if two are successful, that will make them their cash book, you know? …So I think we work at a level of sophistication and technology that they're not ready for.

Such a perspective suggests some movements at UVa to accommodate the external interests of funding sponsors. As another SOI administrator said, "And by working together I think it's cost effective, and they can have some benefit. They get intellectual power of the university. …Small investment, but the pay offs are big." But reliance on industry funding may not be sustainable, the respondent added, for "industry, [if] they're not happy, they can leave…." While SOIs do position to benefit industry to give them access to technologies and early results "they would otherwise not have gotten," a third SOI administrator remarked, they also give faculty members the opportunity to "stay on the cutting edge." Thus institutionalization (e.g., status/standing) facilitates some recourse to academic capitalism (e.g., industry partnerships) for resource positioning.

At UIUC, a number of SOIs aim to network with industry partners and help industry network with other industry members. Recall that one campus official said, "We have ideas, and we want to get people to give us money to pursue them." Science within an endless frontier, as Vannevar Bush long ago envisioned, requires ceaseless pursuit of fluidity and continuity of money. "Part of it is motivated by, you know, getting financial support," an SOI administrator said. SOIs can take federal R&D funding to form widespread collaboration with "even bigger" results for industry and the economy, and as the respondent elaborated, "[W]e provide a lot of opportunity for interaction among the companies, so, companies that have never met might say...'Could we combine our resources together to do something that's even bigger?'" Such a perspective suggests motives beyond securing money for pursuit of research ideas. It indicates an academic capitalist drive to transform industry by way of exchanges of information, technology, money, and people.

Initiatives in this way could prompt some backlash at UIUC. Another SOI administrator observed: “Some people in social sciences don't like…industry relationships. So they object…that we are ‘selling’ ourselves to industry and [giving up] fundamental research and so on and so forth. …So when this criticism comes in I say take your cell phone, this was designed here [in the U.S.], made in China. If you're so averse to it, just throw it away…we are not living in [the] Stone Age now, and this was all brought about by engineers and combination of these factors that we just directed.” Some SOIs aim to increase their funding for research opportunities to benefit society. An SOI administrator discussed focusing on data analytic tools, for “the whole idea of individualized medicine and smarter healthcare…that's a data problem…there's huge opportunity in that space.” From technological advancements of SOIs in particular, UIUC can attract industry money and partnerships whose outcomes can reaffirm UIUC’s scientific prominence.

At SBU, some SOIs have direct links to private industry by way of their research area and market-niche for potential application. To develop research that aims to improve human health requires substantial resources. Here we typically encounter the “valley of death” in which federal R&D funding ends before investigators have enough resources to advance their work to proof-of-concept phases. Recall that one SOI administrator said of pursuits to stabilize research funding for projects, “I mean, ‘continuity’ and ‘funding’ are two words that do not belong in the same sentence.” As one faculty member said, “The expenses are probably a little bit less than in an experimental group where there are a lot of supplies that you go through…[but] computers are expensive. They do break. Data storage…that costs, and then it's just the stipends for personnel [that] also are a big chunk. So…I would say that everybody that is in this area [is] funded, mostly by the National Institutes of Health, but then also to some degree from the National Science Foundation, Department of Energy….”

Here, we can see some recourse to—and a degree of ascendancy of—academic capitalism. One faculty member described how a dean

> would trot visitors through my office every once in a while, and I'd give my little demo. And one time…I was very impressed by the guy who came through. He was a businessman, but he was a smart guy, and he seemed to me to be…underutilized. He seemed like he didn't have as much action as he should have for someone of his ability. …And so I encouraged him that we should talk about this. I think that…there was a company there. And he basically agreed and then we drafted a business plan and things like that.

Of partnerships with industry another faculty member said:

> Well…they're all about reducing risk. It's called "reducing risk," right? So the lower the risk, the more likely they are to get involved. And that means you have to be as far along in the process as possible. Now, we do have mechanisms to protect the intellectual property that we develop, and the university's interested in helping us identify partners that we can partner with to try and develop some of this IP. Some of us…so I've started my own company to try and do this. In other cases, people find ways to interface with existing…companies or other companies, whatever your area of research is who might be interested in your discovery. So I think you have to keep the lines of communication open.

The Center of Excellence for Wireless Information Technology provides an example: it takes state funds to subsidize its work, applies for federal R&D funding, and provides a space and resource for emerging companies that can foster job growth in New York state. An observer explained how "we go after NIH, NSF, DARPA, Navy, everywhere, and especially nowadays, faculty shoot in every direction." Centers and institutes, the respondent added, are often "standing on two legs, one is the academic, the other one is the industry."

Yet other SOIs mediate some leanings toward academic capitalism. Not all centers and institutes, for example, have been "successful in…getting a program project grant," an SOI administrator explained, "which would be one of the…major advantages to do this." Competing for external resources suggests a degree of market-like behaviors within the theory of academic capitalism. But, as the respondent added, when some SOIs at SBU do not secure federal grant funding, they often adapt to reduce costs of conducting science rather than looking to private sources of financing. Recall that the Center for Developmental Genetics encourages its faculty members to share supplies, such as sucrose, to lead to efficiencies in purchasing and also foster collaboration. Federal R&D funding still appears to set incentives around which this and other SOIs at SBU develop and adapt, but does not necessarily trigger pursuit of alternative revenues. Interestingly, the Simons Center for Geometry and Physics does not pursue federal R&D funding since it has a robust endowment from philanthropic gifts. Seeking donor money reflects an increasingly prominent form of academic capitalism. In this way, SOIs and institutions can leverage private dollars to finance initiatives to capture federal R&D funding. Contrary, though, to such trends, the Simons Center may be an example of *resistance* to this form of academic capitalism. Its business model, of harnessing philanthropy to buffer from other competitions for external money, suggests that one strong source of resources (e.g., a philanthropic gift) can purchase some autonomy from pursuing incentives in the broader funding environment.[65]

At UF, the positioning of SOIs for industry involvement varies on campus. For some a business model that utilizes federal R&D funds to then seek additional resources may serve faculty interests well. It can stabilize funding to sustain long-term research projects, increasing the likelihood of discoveries and advancements. "Now, you know we all lose money on research," an emeritus campus leader said. "We lose money on research, and we lose money on patents mostly." Another emeritus campus leader said bluntly, "The university research enterprise loses money, and the institution must find surplus funds to subsidize research since grants never pay the full cost required to do the work." According to one department chair, for an incoming federal R&D grant "a lot of those dollars are already sunk. I mean, you've got to pay…students, and if you're doing something in the biological sciences experimentally, it's very expensive to run a lab, and then…if you have an interruption in funding, it's really hard to recover from that, and if you're doing experimental biology, it's really, really tough."

In this way, an SOI administrator explained, faculty members could transition from scrambling for funding to leveraging the unit for ongoing access to resources. The NSF I/UCRC, when successful, provides an example. An observer said:

> I call it the "tough love model," which is we're going to teach you to be self-sufficient because you're going to have to be self-sufficient to even get started, so we're going to provide you with seed funds that'll help pay for the workshops you'll need to get people together, it'll help pay for your coordinator or other administration where you

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[65] The Simons Center focuses on theoretical physics and mathematics, disciplines with relatively low levels of federal R&D funding among mission agencies. That said, the Center could still seek federal research grants despite the "hit rates" and odds of success, but chooses not to.

> need help, but that's it. And everything else, you'll have to bring in from your own partnerships, your own devices.

While some centers and institutes at UF offer a natural overlap with industry and government agency partners, they do not always secure money from them. According to one SOI administrator, biotechnology companies can be "helpful with advice…[but] getting them to open up their checkbook is another story." Academic capitalism seems ascendant in *aspirations* but somewhat tempered in the business models and behaviors of the SOIs at UF.

Summary

As presented in this chapter, six core themes have emerged from the cross-case analysis: SOIs, though largely intended as short-term, adaptive units, are politicized and when formed seek to endure. Part of their pursuit for viability entails their serving to strengthen the medical-research enterprise, implying some hegemonic qualities of the medical profession rather than the outright mimetic, isomorphic tendencies within the field of higher education. In efforts to deepen their own and their institution's status/standing (e.g., institutionalization) and resource position, the SOIs tend to provide opportunities for co-optation-like initiatives to "infiltrate" the funding priorities and outlays of mission agencies. The SOIs, which reflect scientific niches of expertise/specialization, offer clout to faculty members in the scientific community but also campus leaders in prestige-battles among the academic elite. Indeed, research (and funding) accomplishment disproportionately positions star scientists for administrative/financial leadership of SOIs. Yet academic capitalism—in part underpinning SOI engagement with industry in pursuit of fluidity and continuity of research and money—seems not quite ascendant but mediated/buffered among the SOIs. To be sure, the extent to which the SOIs (e.g., cases) reflect these themes varies some by institution and quadrant of innovation. Conceptual and practical implications of this variation are discussed next in Chapter 7.

CHAPTER 7

DISCUSSION AND CONCLUSION

In recent years, many research universities have undertaken substantive structural changes to advance science and secure external resources. To develop the academic core these adaptive institutions often "tinker" with existing units and create new ones (Geiger & Sá, 2008, p. 162). The elaboration of matrix forms of organization, entwining various campus entities in networks, may contribute to *fluidity* and *continuity* of knowledge-production, money, and people. It aims to facilitate exchanges of resources throughout an institution and in external partnerships with government- and industry-stakeholders, while ensuring that such exchanges can stabilize and remain viable.

Despite experimenting with new forms of academic structure, numerous research universities continue to receive criticism for lack of adaptability. The National Academies has called for institutions to pursue matrix forms of organization to best meet interdisciplinary demands and funding opportunities in STEM. It suggests that academic communities *should* develop new organizational forms on campus, for campus constituents tend to "accommodate their aspirations and plans to the possibilities…in the institutional structures around them" (National Academies, 2005, p. 174). Analogous to some external groups' perceptions of research universities, leaders within institutions voice concerns over the "insufficient focus [that] has been devoted to…the organization of a knowledge enterprise and the social formations and knowledge networks its configuration engenders" (Crow & Dabars, 2015, p. 179). The changes taking place on campuses may not be enough, these observations suggest, for success in this arena.

This thesis has focused on one particular type of change at research universities: what I term STEM-centered organizational innovations (SOIs). As defined in this study, SOIs are centers, institutes, schools, and departments formed in federally funded areas of scientific research. Included here are those units formed between 2000 and 2014, a time period that, for analytical purposes, allows for an adequate sample of the most recent emerging organizational forms new to their home institutions. This thesis features 35 SOIs that are distributed rather evenly across the four sampled institutions of the University of Virginia (UVa), University of Illinois at Urbana-Champaign (UIUC), Stony Brook University (SBU), and University of Florida (UF). By examining them, we may develop conceptual and practical understandings of what SOIs are—and the external and campus-level influences that underpin them as adaptive entities.

To study the SOIs empirically, this thesis has employed a multiple embedded cross-case analysis. The case is SOIs within one institution (e.g., UVa) that is then compared to SOIs (e.g., cases) at three other institutions (e.g., UIUC, SBU, and UF). This thesis has aimed to assay the nature of variation of SOIs among research universities, but also pinpoint the external and campus-level influences on the emergence of SOIs. Thus the cases have been situated within their respective institutions, which fall within a quadrant of innovation based on dimensions of high or low institutionalization (embedded status/standing in the AAU) and strengthened or threatened resource position (pattern of federal R&D funding over time). Such an approach has yielded the following institutional sampling scheme:

- UVa from Quadrant I: High Institutionalization/Resource Strengthened
- UIUC from Quadrant II: High Institutionalization/Resource Threatened
- SBU from Quadrant III: Low Institutionalization/Resource Threatened
- UF from Quadrant IV: Low Institutionalization/Resource Strengthened

In this way, the research design has helped to address key knowledge gaps about SOIs themselves, the roles of status/standing and federal R&D funding in organizational innovation, and "ground level" accounts, by way of case-study analysis, of administrators and faculty members whose entwinement drives and shapes change on campuses.

A number of intriguing findings emerged as reported in Chapters 5 and 6. This chapter first presents a summary of the core empirical results of the thesis. Then it addresses conceptual implications, followed by considerations for institutional policy and practice and directions for future research. To close the thesis, this chapter offers concluding remarks that intimate developments to come in this arena.

Summary of findings

As the within-case findings of Chapter 5 suggest, there are both some expected and unexpected results that have emerged in this thesis. On the whole, SOIs aim to boost research activity that increases an institution's share of federal R&D funding. But when the SOIs are situated within their respective campus-contexts of institutionalization and resource position, they indicate some notable inconsistencies.

To summarize the main takeaways from the *within-case* findings:

- UVa, in the high institutionalization/resource strengthened quadrant, has status/standing and money to innovate boldly. But its SOIs suggest rather tight normative and financial margins for innovation: predominantly *virtual* centers and institutes, these units may lead to promising advancements in science, while operating around UVa's core academic structure and related financial commitments. To this end, the SOIs constitute a "network of support," as one SOI administrator described it, to open research collaborations, share money vis-à-vis internal seed-funding, and heighten responsiveness to external funding opportunities.

- UIUC, in the high institutionalization/resource threatened quadrant, has legendary status/standing in science, and its SOIs reflect the caliber of scientists and research agendas on par with the institution's Nobel Laureates of the past. A resource threatened position seems to prompt a potentially novel direction in American higher education, an ambition to create an engineering-oriented medical enterprise on campus that may advance further UIUC's reputation for scientific excellence. Within this context, SOIs cover a range of forms (virtual and capital-intensive centers, institutes, schools, and an academic department) and also compete for resources and visibility. Their individual successes can affirm UIUC's overall prestige.
- SBU, in the low institutionalization/resource threatened quadrant, exhibits a seemingly tight network of largely capital-intensive SOIs and also affiliated members and supporters (e.g., administrators, faculty members, Brookhaven National Laboratory, donors/philanthropists, etc.). It suggests an environment not immune to politics and competition but of some

palpable cohesion—and loyalty. Recall that physicist Chen-Ning Yang joined the SBU faculty in 1965 after he won the Nobel Prize, and there, he formed and ran the C.N. Yang Center for Theoretical Physics and remained at the institution for 34 years until his retirement in 1999.

- UF, in the low institutionalization/resource strengthened quadrant, has aspirations of eminence that seems to foster a rather competitive environment on campus. A sprawling mix of virtual and capital-intensive centers, institutes, and academic departments, SOIs tend to fight over perceived *scarcity* of "territory…resources…[and] faculty," as one SOI administrator explained. Some respondents in this thesis have doubted whether UF has the financial depth necessary for greatness, noting the departure of talented faculty members for more prestigious institutions.

The within-case findings help us situate the SOIs—their nature of variation and emergence—in context. Indeed, they indicate ways in which institutionalization and resource position together influence the types of organizational forms that are permitted normatively and financially to develop. Yet to work toward robust empirical conclusions, the cross-case findings of this thesis may offer additional insight.

As Chapter 6 suggests, there are six *cross-case themes* that highlight points of overlap and variation among SOIs at the sampled universities. The first and second themes reveal the nature of variation of SOIs, the third and fourth themes reveal environmental influences on the emergence of SOIs, and the fifth and sixth themes reveal institutional influences on the emergence of SOIs. To reiterate the core results:

1. *Competing to survive as political experiments.* SOIs in this thesis are largely formed as adaptive entities but once created seek to endure. Though “experimental,” unproven yet highly leveraged for research and external resources, they are politicized based on their infusion of values, goals, money, and people. They tend to draw on normative and resource claims to ensure viability. Such a finding resonates with classic sociological literature: organizations tend to persist beyond their expiration dates with revised goals after they have achieved their initial set of goals.[66] In this way, SOIs tend to exhibit *goal displacement* to continue to adapt to survive.
2. *Serving the medical enterprise*. The SOIs in this thesis largely align themselves with the medical research enterprise. In turn they may compete for NIH funding but also benefit in status/standing from affiliation with the various niches of specialization within the medical profession. Such a finding may reveal a level of homogeneity—and emulation—within the AAU field of institutions (e.g., copying Johns Hopkins University, which leads all U.S. universities and colleges in federal R&D funding in general and in biomedical, NIH funding in particular). Yet the SOIs in this thesis seem especially responsive to

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[66] For instance, Selznick (1960) found that the Bolsheviks at first focused on mass action for insurrection in Russia, but later, after the party met its initial goal, emphasized less public efforts *within* various agencies to advance the political agenda. Not all entities are, as Selznick has depicted here, “organizational weapons” for revolt and subversion; however, many share in common *developmental processes* as part of cycles of growth and maturation. Among SOIs, the active revision of goals may indicate an ongoing process of organizational development by which to achieve equilibrium on campus and in the external environment.

influences from the *medical field*, a field whose members may subsume other social institutions for professionalization.[67]

3. *Positioning to co-opt federal funding streams.* In relation to the external environment, SOIs are platforms of "infiltration" of federal mission agencies, as a campus official at UIUC said. The emphasis here has not necessarily been on *full* co-optation of mission agencies, but rather on shaping the funding priorities and outlays for emerging research areas. Such a finding reveals mechanisms of resource dependence theory. Analogous to many private corporations, which actively seek to change their regulatory environments, SOIs in this thesis can facilitate exchanges of information and people between campus and mission agencies. In turn some faculty members can steer requests for proposals (RFPs) toward their strengths, while others increasingly access the peer review process.
4. *Strengthening prestige-claims among the academic elite.* SOIs provide the basis for prestige-claims among the academic elite, whereby campus leaders tout institutional expertise/specialization of scientific strengths. In other words, campus leaders "cash in" emerging organizational developments and funding-success in STEM for recognition and renown. Such a finding seems to fit well with institutional theory: SOIs may not

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[67] As DiMaggio (1988) notes, medical professionals and health care institutions have gained legitimacy from affiliation with universities. Positioned as such, physicians and hospitals may thus support claims of offering expertise and specialized services. Yet once emerging professionals and institutions achieve some independent status/standing, DiMaggio observes, they may distance themselves from the institutions that have helped them to develop. In this way, the medical field may actively *institutionalize* but could, as a consequence, come to *de-institutionalize* the universities that it has leveraged.

necessarily be effective in knowledge production, but elevate the image—the appearance—of scientific prominence and thus institutional relevance.

5. *Privileging access to administrative/financial authority.* SOIs provide disproportionate access for scientists to administrative/financial authority. Faculty members with strong research accomplishment have legitimacy among campus leaders and peers to drive organizational change. Not all elite researchers become leaders of SOIs. But there is some overlap in the elaboration of organizational structure and the rise in opportunities to gain additional control of administrative and resource stewardship. Such a finding suggests academic capitalism: as the number of SOIs increase, the *composition* of administrators and staff on campus also increases. This trend seems to reflect broad movements in higher education toward managerializing faculty members but also stratifying the professoriate in favor of those in the STEM arena.
6. *Mediating the ascendancy of academic capitalism.* SOIs nevertheless seem to temper some the ascendancy of academic capitalism. Without doubt several SOIs utilize federal, state, and institutional resources for research partnerships with industry, collapsing further organizational and financial boundaries in knowledge production. Some SOIs in this study owe their development and survival to industry money that purchases technological advantages (e.g., the Center for Automata Processing at UVa). Though still relatively young in years, a number of SOIs in this thesis appear to be for "sale" to sponsors for funding to stay alive. They

> are often bought and sold by mission agencies, industry partners, institutional leaders, and campus and department administrators (e.g., deans, directors, chairs, etc.). Such a finding may suggest SOIs as actively facilitating the rise of academic capitalism; however, this thesis indicates that SOIs often *repurpose* external influence/funding for cutting-edge research to certify visibility within the scientific community.

Analogous to the within-case findings, there are some inconsistencies in the cross-case themes. Likewise, the variation here tends to surface at the nexus of institutionalization and resource position of the sampled institutions. In the next section, this chapter discusses conceptual implications of these empirical results and emphasizes that which differentiates the findings of this thesis from prior, related work in this arena. To this end a re-conceptualized quadrants of innovation model can be presented.

Implications for theory

Three theories have informed this thesis: institutional theory, resource dependence theory, and academic capitalism. In relation to these theories this study's empirical findings offer several contributions. This section highlights the core concepts of each theory, as well as the ways in which the findings of this thesis, broadly considered, may extend understandings of the nature and parturition of SOIs.

Institutional theory. As institutional theory suggests, organizations become institutions when they are infused with value and meaning beyond their technical efficiency. Institutions may drift toward then stabilize structurally around the normative expectations of stakeholders, while also decoupling their external appearances from core activities for managerial discretion (Meyer & Rowan, 1977). In this way institutions aim to uphold “charters” with society, affirming their importance—their relevance—to those that fund them and also endow them with political support.

Throughout this thesis, institutional theory has served to explain various layers of organizational change. Among SOIs, we may anticipate seeing the increasing alignment of emerging academic structure with federal mission agencies. The continua of SOIs at each sampled institution represents responsive change in the research core that positions for legitimacy in knowledge production and for resources. Institutional theory also offers an explanation of the *context* of structural innovation. This thesis has argued that institutionalization (e.g., embedded status/standing) of research universities in the AAU shapes the nature and emergence of SOIs. Here, *history* matters. As the findings of this thesis suggest, history matters in some intriguing, unanticipated ways.

According to institutional theory, the various entwinements and commitments of institutions are considered to thwart change and underpin some inertia. They delimit possibilities of and acceleration toward change, protecting and locking in that which institutions are expected to be and do. Selznick (1992, p. 232) articulates the dominant perspective when he writes:

> The underlying reality—the basic source of stability and integration—is the creation of social entanglements or commitments. Most of what we do in everyday life is mercifully free and reversible. But when actions touch important issues and salient values or when they are embedded in networks of interdependence, options are more limited. Institutionalization constrains conduct in two main ways: by bringing it within a normative order, and by making it hostage to its own history.

A “normative order” does not necessarily control what institutions can be or do, but tightens the margins around which they may change and adapt. The external relationships that institutions form and stabilize, based on shared understandings of values, can become historically engrained and thus hold institutions “hostage” to prior courses of development. Yet as this thesis shows, *history is often a source of innovation*.

Among the *high institutionalization* sampled institutions, UVa and UIUC, longstanding prominence has in part motivated the formation of SOIs. For instance, UVa is inextricably linked to its founder, Thomas Jefferson. Its “history [may seem] an anchor that drags us back into the 19th century,” a campus official said, “but…Jefferson himself was a great innovator, and he loved technology.” We can see the undercurrents of history in some of UVa’s most recent SOIs, such as the Center for Automata Processing. It formed in 2014 from seed-funding from nanoSTAR (UVa’s nanotechnology-focused institute) and Micron’s investment in core computing hardware for “big data” analytics. The Center partners with UVa’s Data Science Institute, private corporations, and other universities to compete for continuity of funding for projects. Analogous to UVa, UIUC leverages history to change and adapt to continue to rise in reputation and resources. As a former campus official explained, the university is “either moving forward or…likely in a period of decline.” SOIs, such as the Institute for Genomic Biology, latch onto an “animating idea,” an SOI administrator said, of national importance and fundability.

Institutionalization, this thesis suggests, is not only cultural and reputational in terms of status/standing but also financial. As Kraatz and Zajac (2001) observe, institutions tend to reinvest in already-existing commitments to minimize risk and uncertainty. Focusing on longstanding relationships, for instance, may be less costly in terms of displacement of resources, goals, and values than pursuits of new ventures and stakeholders where future outcomes are difficult to predict or are unknown. Among

SOIs, we often see them emerging in areas of historical academic strengths and federal funding. Such consistency—such continuity—could come from the need for faculty members to demonstrate specialization and expertise in particular niches of science. Yet, as this thesis suggests, the institutionalization that shapes SOIs, in both their type and scope, may be budgetary. As one respondent at UF explained,

> The key is always the budget. *The budget is the current and historical statement of the institution's values.* It is what the university decided yesterday and in the past to pay for, as well as what it decided not to pay for. If you want to change the university, you have to change the budget to match what you say you believe in. If you believe in research competition against the best, but you pay for political and personal relationships among faculty, administration, alumni, trustees, and politicians, then you'll get optimization of personal relationships. Often it is best to try and make sure everyone sees what the values are and can see how the budget reflects those values. (Emphasis added)

Thus, to paraphrase the National Academies (2005) report, academic communities aspire to possibilities in not only the structures around them, but also the money.

As these implications suggest, *the interplay of institutionalization and resource dependencies contributes to the nature and parturition of SOIs*. Tension between institutionalization and resource dependence—how that tension is experienced, resolved, or heightened—underscores change in the research core of the sampled universities. It may thus be helpful to reiterate the role of resource dependence theory in this thesis and the related empirical findings.

Resource dependence theory. Resource dependence theory suggests the interpenetration of organizations and external environments. To increase self-autonomy and managerial discretion, organizations may drive initiatives to lessen their reliance on any one stakeholder or resource provider. The end-game is control, "the ability to initiate or terminate actions at one's discretion" (Pfeffer & Salancik, 2003, p. 259), and power, "the ability of persons or groups to extract for themselves valued outputs from a system in which other persons or groups either seek the same outputs for themselves or would prefer to expend their effort toward other outputs" (Perrow, 1986, p. 259). In relation to their external environments, universities may develop and leverage SOIs to broaden research-funding streams. Yet on campuses SOIs may be disproportionately rewarded for contributing to their organizations' "slack resources" from external grants. SOIs, then, may reflect micropolitics among competing units but also dynamics of the broad political economy that shapes social institutions (e.g., Jong, 2008; Trow, 1999).

In this thesis, the percent change in federal R&D funding has been considered a strong trigger of organizational change and adaptation. Recall from Chapter 4: in 2014, HEPI-inflation adjusted dollars, the federal government provides annually about $29 billion in R&D funding to colleges and universities. Institutions, states, and industry each contribute to resourcing the academic research enterprise, but not nearly as much as mission agencies (Stephan, 2012). As expected, SOIs at the resource threatened institutions in this study, UIUC and SBU, position to increase shares of external money. Consistent with some recent observations (e.g., Geiger & Sá, 2008), we also see active innovation among the resource-strengthened institutions in this study, UVa and UF. There, SOIs help to affirm the cutting-edge in science for continued funding (e.g., at UVa) and to vie for a "bigger pot of money," an SOI administrator at UF said, in terms of sponsors.

The SOIs and institutions in this study, however, do not necessarily seek to broaden resource providers. As resource dependence theory suggests, organizational adaptation may occur to lessen reliance on any one funding sponsor. If anything, we see among both SOIs and institutions an increasing *convergence* around interests of the NIH and niches within the biomedical arena. It seems that institutionalization—the pursuit to strengthen status/standing among the academic elite—may account for gaps in the analytical purchase of resource dependence theory. Oliver (1991) suggests that resource-strong institutions, with relatively low levels of external dependence, may actively resist or defy normative influences to respond to institutional pressures of change. Yet in this study, *money is often used to purchase status/standing in a field, but does not always widen the normative margins (e.g., "rules of the game") for innovation on campuses*.

In directions of organizational adaptation, UVa's high institutionalization mediates any latitude that strong resources could "buy." It does not necessarily hold UVa back from innovation, but shapes the structural possibilities that can develop/endure and informs the allocation of money. At UIUC, money is needed to make sure that the institution does not slip in its reputation of scientific eminence among peers in the AAU. Indeed, at SBU, we see SOIs as creatively leveraging external partnerships and key philanthropists for resources needed to piece together fluidity and continuity of funding and research. But such efforts at SBU, as elsewhere in this thesis, are relatively locked on the biomedical, NIH arena. Among SOIs at UF, we see the importance of money in coordinating a matrix organizational hierarchy and in attracting preeminent faculty to elevate further the institution's federal R&D funding for status/standing.

At each of the institutions in this thesis, then, SOIs largely pursue resources within "rules of the game." They reflect some creative structural developments that fit field and campus contexts of institutionalization and resource position. In particular, the

SOIs across the sampled institutions are largely ensnared with—and somewhat constrained in their possibilities by—a delimited set of funders of research whose money determines prestige in the scientific community and AAU. When they are brought together, institutional theory and resource dependence theory can shed some light on the normative and financial margins around which SOIs develop and seek to endure. But the two theories do not adequately explain or critique influences of the political economy on organizational change and adaptation in research universities. In this way, the theory of academic capitalism may offer some explanatory power.

Academic capitalism. The theory of academic capitalism situates organizational change of research universities within the surrounding political economy (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2014; Slaughter, 2014). In the U.S., and increasingly abroad, the legal, regulatory environment incentivizes *market-like* and *market* behaviors of social institutions. Using public subsidies, these institutions compete for external monies (e.g., market-like behaviors) and aim to generate profits from markets (e.g., market behaviors). Within universities, we may view SOIs as new academic units that form at interstices of fields and disciplines and help to prompt emerging networks ("circuits of knowledge") among institutions and external organizations. In relation to the findings of this thesis, academic capitalism may account for broad contextual influences that are entwined with the nature and emergence of SOIs.

SOIs across the sampled institutions do compete and, in some cases, have explicit motives to generate profits from intellectual property and technological developments. What is more, some SOIs are actively bought and sold as they adapt for funding from various sponsors to stay alive. As some researchers and analysts have observed, even when SOIs have explicit closing dates as part of their funding, they are still known to have "lived on forever" with "more funding through various re-inventions."[68] In this thesis, SOIs seem to reflect academic capitalism as commodities for purchase by institutional actors (e.g., central administrators, college deans, school directors, etc.) and also philanthropists, mission agencies, and industry sponsors. Yet the SOIs, on the whole, offer opportunities to faculty members to solidify their scientific expertise by pursuing and publishing research in emerging, specialized niches. That is, academic capitalism, in practice, may lead to resources to finance research of market value and also of merit and relevance to the scientific community.

Such a finding, of buying and selling organizational units for money and affirming commitments to the scientific community, may not necessarily be entirely incompatible with the theory of academic capitalism. As Slaughter and Rhoades (2004) acknowledge,

> Although we see the academic capitalist knowledge/learning regime as ascendant and have sharply delineated boundaries between the two models for analytical purposes, academic capitalism has not replaced the public good knowledge regime. *The two co-exist, intersect, and overlap.* For example, securing entrepreneurial revenue streams, a focus of the academic capitalism knowledge/learning regime, has become more important but has not replaced the research prestige associated with the public good knowledge regime. (pp. 29-30, emphasis added)

Within the markets for them, their faculty members, and the knowledge they produce, SOIs often have monetary value. The purchasing of academic units, especially by external actors, raises questions about the underlying reward systems for faculty

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[68] I am especially indebted to Sheila Slaughter (personal communication, September 25, 2015) for these comments that have helped me think through more carefully the connections between SOIs and academic capitalism.

members. Indeed, there is evidence to suggest that some faculty members are increasingly sensitive to market incentives in terms of leveraging federal R&D funding to commercialize their research (Johnson, 2011). *But, as this thesis suggests, SOIs seem to blur boundaries: they appear to harness mechanisms of academic capitalism to finance research that may lead to prominence in markets and also in the scientific community.*

Academic capitalism further explains the shifting social relations among administrators and faculty members on campuses. The theory suggests the rise of managerial capacity to steer—and at times control—institutional moves to markets. An increase in managerial capacity and authority does not necessarily mean outright erosion of unit-level and faculty member autonomy. But the theory is helpful in raising questions about change and adaptation in administrator-faculty roles and boundaries.

As this study suggests, many faculty members are actively involved in organizational change. They co-lead, with administrators, the formation and ongoing development of SOIs. Such a finding brings to mind Gumport and Pusser's (1997) perceptive observation that "the structural elaboration of higher education organizations must be accounted for with reference to not only what changes but how and by whom" (p. 456). In the context of academic capitalism, this thesis reveals evidence of *cross-institutionalization of bureaucratic forms of academic structure and scientists as administrators.* The SOIs reflect the evolving density of organizational units on campuses, as well as the positioning of scientists—rather than administrative professionals per se—for administrative and financial roles and careers. Of course, many academic administrators are faculty members, for they have often progressed through the faculty ranks and continue to hold academic appointments.[69] Yet, as this thesis suggests, SOIs seem to create administrative/financial opportunities for star scientists who may continue to benefit in their research and scientific prominence from selective access to these resources.

Overall, the conceptual implications of this thesis may help us re-consider dynamics within the quadrants of innovation. Institutional theory, resource dependence theory, and academic capitalism suggest some possible *causal* mechanisms of structural innovation on campuses. The empirical aim and case-study evidence of this thesis may preclude such definitive claims about the precise antecedents of SOIs. But this thesis can help us specify relationships among factors that seem germane to the nature and parturition of emerging organizational forms in the sampled universities.[70]

Re-conceptualized quadrants of innovation model. Figure 12 presents a re-conceptualized quadrants of innovation model, which the guiding theories and empirical findings of this thesis have informed. In Quadrant I, high institutionalization and a resource-strengthened position set a context of constraint. At UVa, for instance, SOIs often reveal strong normative claims to demonstrate fit, and they largely form with

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[69] Jerome Weisner, president emeritus at MIT, provides an example: he was an accomplished professor in electrical engineering prior to becoming, in the 1970s, a university president. He was also selected to join President John F. Kennedy's Science Advisory Committee.

[70] The four sampled institutions in this thesis are largely representative of their respective quadrants based on dimensions of institutionalization and resource position. But empirical findings about them and their SOIs (e.g., the cases) may not necessarily generalize to all other research universities. Academic units on campuses have not always been viewed among researchers and analysts as representative of organizations in general, though, as Hearn (2007) notes, such a perspective may be shifting. Nonetheless, this study's data allow for re-conceptualizing broadly what we may anticipate finding elsewhere. From campus to campus and organization to organization, entities all share in common relative degrees of institutionalization, resource positioning, structure (e.g., units and subunits), and goals.

minimal institutional investment. There are some exceptions to this pattern: consider the Applied Research Institute, which focuses on defense-related contracts and grants and whose faculty members work, though not exclusively, on classified research. While such an SOI can trigger pushback, perceived as serving the interest of "spies," it still nonetheless leverages UVa's history to suggest its fit ("Thomas Jefferson used spies all the time," a respondent noted). On the whole, within the context of UVa's status/standing and resources, SOIs are mostly virtual yet highly networked among each other in order to survive.

In Quadrant II, high institutionalization and a resource threatened-position undergird aspirations of profound change. If implemented successfully, such plans can reorient the institution toward bold, new directions. At UIUC, for example, relatively flat growth over time in federal R&D funding has in part motivated efforts to create a novel engineering-medical enterprise. The initiative could strengthen UIUC's visibility in the scientific community and also open new funding possibilities vis-à-vis the NIH. Here, the SOIs that form are diverse, encompassing a range of different types of organizational units, and also competitive for resources to fortify status/standing.

In Quadrant III, low institutionalization and a resource-threatened position opens a pocket of latitude for structural innovation. Normative margins are defined but are not necessarily so deeply engrained and restrictive. The drive to improve resources, within somewhat flexible normative margins, may contribute to a range of creative, external partnerships for research and resources. At SBU, for instance, the SOIs that form are mostly capital-intensive and highly networked within and beyond campus. Interestingly, such a setting may nurture a collaborative ethos among faculty and loyalty to the institution.

In Quadrant IV, low institutionalization and a resource-strengthened position fosters a degree of imbalance. Strikingly, the aspiration to ascend in status/standing may distort perceptions of the amount of money/depth of resources already on hand. This elicits some political tensions, where ambitiousness/competition is heightened but resources are actually perceived as scarce. At UF, for instance, the drive for eminence seems to yield a wide variety of different forms and types of SOIs (e.g., virtual and capital-intensive); it underscores aggressiveness in structural innovation, but also increasing competition among SOIs for resources and people. The key issue here becomes one of coordination—how to link various, diffuse units and steer/finance them toward collaboration.

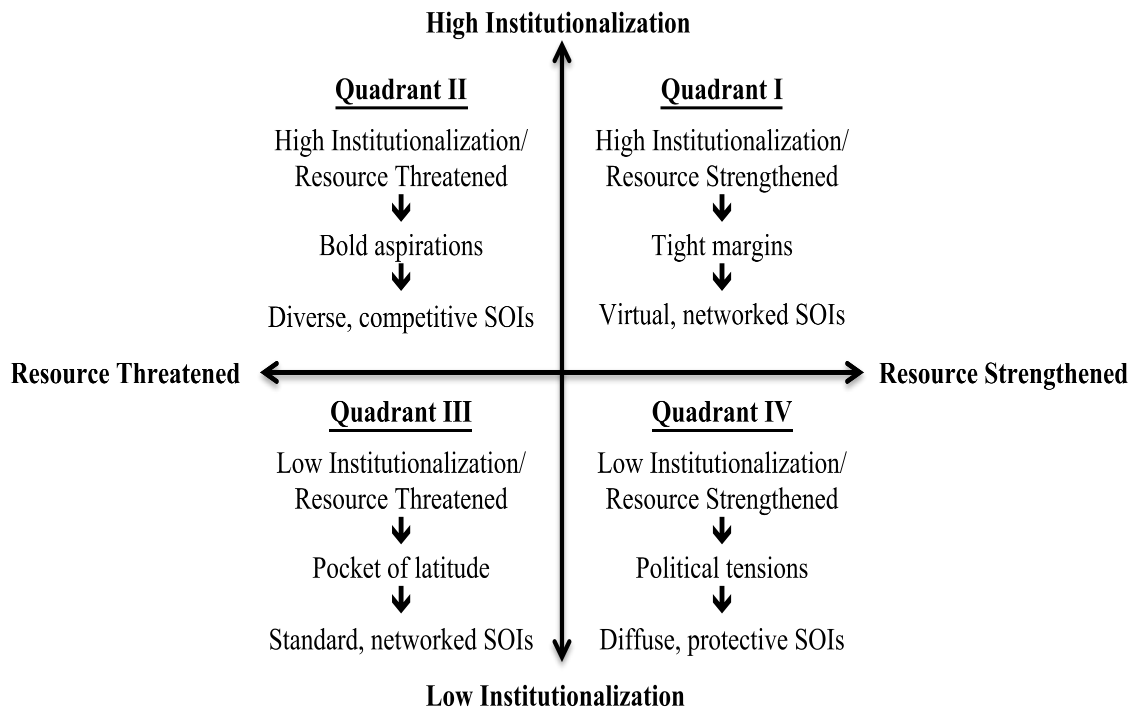

Figure 12. Re-conceptualized quadrants of innovation model.

The conceptual implications of this thesis suggest some contributions to the research literature on this topic. Yet empirical results of this study lead as well to several considerations for institutional policy and practice. This chapter addresses them next.

Implications for institutional policy and practice

Three research questions have guided this thesis. As stated in Chapter 1 and restated in Chapter 4, they pertain to (1) the nature of variation of SOIs among research universities, (2) the influence of the external environment on the emergence of SOIs, and (3) the influence on institutional context on the emergence of SOIs. This section groups implications for policy and practice by each question-area.

Nature of variation

The SOIs in this thesis exhibit great experimentation within and across the sampled institutions. On the whole they feature a range of units by which to calibrate and coordinate investment and risk in structuring to advance science. *Yet it remains unclear, in this study, the precise continua of SOIs that are most effective.* What is more, we know little about whether strategic management and organizational design, as advocated in literature and theory (e.g., Crow & Dabars, 2015), contributes to success in knowledge production and external resources.

As the findings of this thesis suggest, SOIs can help faculty members (and institutions) demonstrate expertise and specialization in science by which to win status/standing and federal R&D funding. Mission agencies provide center-level grants, but typically do not fund organizational structures per se. They fund people: individual investigators and research teams. In this way, SOIs hold strong potential to allow faculty members to certify further their expertise and visibility in emerging niches of science and external funding. While this could suggest to campus leaders the need to integrate SOIs within a broad administrative, funding structure (e.g., Ikenberry & Friedman, 1972), a note of caution is required. *We do not know the extent to which any given SOI is adaptive or maladaptive in efforts to strengthen knowledge production and secure external resources.*

Institutional leaders and campus officials are thus rightfully looking for ways to balance their own and faculty's influences in organizational change. As Rhoades (1990, p. 210) has put it, when "swashbuckling deans and their motley crew of faculty" work together, and within the broad institutional context, they may implement and sustain substantive organizational change. As this thesis suggests, SOIs often form—and carry the legitimacy to self-sustain—from the initiative of faculty members. For institutional leaders, from presidents to senior staff to deans, their support continues to be crucial especially in the forms of allocation of space, faculty lines, and money. SOIs may largely take on lives of their own, isolating them from centralized authority and oversight, but will "listen to money" as universities themselves do, a former SOI administrator said. The differentiating of funding for SOIs, privileging some over others, is not necessarily wrong or counterproductive. But developing and implementing *criteria* for such funding decisions is a key issue: *who should prosper, by how much, and at what cost to others?*

From the perspective of institutional theory, institutional leaders and SOI administrators may want to consider closely the question of *what business they are really in*. The academic enterprise is complex organizationally, and at research universities, knowledge-production is important but only one part of the mission. Developing SOIs to strengthen the research core should thus be considered as one part of broad institutional portfolios of goals, operations, and resources. The extent to which structural recourse to federal R&D funding and status/standing comes to predominate could suggest erosion—and maladaptation—of institutions away from their full set of pursuits and commitments.

External influences

The federal government provides strong incentives for research universities to adapt and change to the shifting budgets and priorities of mission agencies. Yet a number of respondents in this study indicate that financial costs often outweigh the revenue benefits of federal R&D grants. That is, institutions may be successful in receiving external funding, but do not receive enough to cover the costs of executing the work for which the grant subsidizes though does not pay in full.

Institutional leaders and faculty members may each and together form SOIs for various reasons. As adaptive entities, SOIs can help individual and teams of researchers to respond quickly to external funding opportunities in interdisciplinary spaces. *They may, in relation to the financing of the academic research enterprise, facilitate economies of scope and scale that limit potential revenue losses on external grants.* With the increase in number of SOIs over time, a campus may broaden its range of research coverage and gain efficiencies by expanding to an optimal point its operations in knowledge production (e.g., economies of scope). At the same time, the scientific and funding productivity that could come from SOIs may contribute to efficiencies. Recall that virtual SOIs in particular draw on existing institutional infrastructure and therefore minimize investment while also boosting the amount of research taking place on campus (e.g., economies of scale). In this way, SOIs could be helpful to campuses that aim to work around some of the inefficiencies inherent in externally funded research.[71]

Yet institutional leaders may want to consider whether they are too focused on federal R&D funding to finance the research enterprise. Institutions by way of SOIs may demonstrate alignment with national needs and interests when they win competitive grants; however, a profitable, efficient research core is not guaranteed and, even with

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[71] Some SOIs may contribute to administrative efficiencies in grant-management. For instance, SOIs could participate in consortial purchasing, accounting, and job sharing. Such a feature may be especially prominent among SOIs with direct ties to already-existing academic departments and schools. Tapping into departmental administrative support, for instance, could free-up time and resources for an emerging center or institute. As an SOI administrator at UF said, an affiliate department on campus "could live without us, but we [in our center] couldn't live without them."

experimentation in academic structure, difficult to achieve. Thus for financial viability institutional leaders may want to consider alternative ways of stewarding their communities—and broaden their focus on other areas of research. They may strive for *fluidity* and *continuity* of research, money, and people, but such an outcome may not necessarily be attainable given the economics and resource dependencies of academic research.

The AAU has contributed some influence in perhaps locking institutions into intensive focus on federally funded science. It has been intriguing to see some variation in institutional responsiveness to the AAU, ranging from oft-unspoken but felt sense of belonging among the elite (e.g., UVa) to a mix of skepticism/critique and approval (e.g., UF). Clearly not all faculty members at the sampled institutions think about the AAU or form their research agendas around it. But institutional leaders could consider ways in which they may buffer more so the AAU, or broaden self-regulation of the field to ascribe meaning and weight to evaluative metrics beyond productivity in externally funded science (e.g., Carey, 2014).

Institutional influences

As Ikenberry and Friedman (1972) have observed over forty years ago, administrators and faculty members each and together shape the organizational directions of campuses. Across SOIs and institutions in this study, structural changes are entwined with the shifting of scientists toward positions of administrative and financial authority. *Compositionally, as the number of SOIs on a campus increases, so does the number of administrators and staff.* With growth of organizational units, the managerializing of faculty members thus becomes increasingly pronounced. The nexus of (1) elaboration of organizational units (e.g., bureaucracy) and (2) new administrative roles and careers merits some attention.

Brint (2005) suggests that public research universities have embraced "new directions" in interdisciplinary spaces to compete in increasingly complex environments. Such repositioning, he notes, carries implications for the types of leaders that will emerge to steward these organizations. He anticipates movement away from faculty leaders in fields and disciplines to administrative, "creative" types: "Strategies to emphasize interdisciplinary creativity shift a share of control from leaders in the disciplines to those who are experts in aggregating resources and planning large-scale projects." (p. 39). This thesis, however, indicates among SOIs *the rise of the scientist as administrator*.

In their evolving roles and careers, scientists, this study suggests, may be gaining disproportionate access to administrative and financial authority. Such a development contrasts the anticipation of administrative specialists—those trained and credentialed in project management, strategic change, and financial planning. *Indeed, the findings of this thesis further suggest the importance of continued specialization and expertise within academic fields and disciplines.* From visibility and funding success as scientific expert, opportunities arise to enter into administration.[72] Recall that medical researchers and physicians in particular, a respondent at SBU said, often "think they're gods." They

[72] The institutions in this study have strong graduate levels of education, providing infrastructure, resources, and people (graduate students, post-doctoral researchers, administrative staff, etc.) conducive to helping faculty members develop robust research programs by which to certify credibility and expertise in the scientific community. Indeed, an emphasis on graduate education and research at the elites, such as Cal Tech, Harvard, Johns Hopkins, MIT, and Stanford, may contribute in part to their scientific productivity and success in external funding.

influence through the consequences of their work human life and death. Power inherent in their professionalization may underpin the "evangelism" on campuses and in society, the cultivation of believers in science and scientists as healing us, as solving our problems (Greenberg, 2001).[73] Some scientists, as this thesis suggests, may make strong, effective, and visionary leaders, and their research accomplishments entwine them with the status/standing and resources of their institutions. But we may ask whether anchoring the control of organizations around science and scientists is worth it.

Directions for future research

The implications of this thesis for theory and institutional policy and practice point toward several potentially fruitful areas for future research. This section discusses seven prominent directions. Together they reflect angles of exploration within postsecondary policy and organization.

First, *empirical analyses of matrix forms of organization may prove useful.* Some researchers and analysts suggest strategic movements of universities toward matrix arrangements of departments and faculty hiring (e.g., Bolman & Deal, 2007; Hearn, 2007; Geiger & Sá, 2008; Sá, 2008). This thesis has provided initial evidence, albeit to differing degrees, of such interconnections among SOIs within the sampled institutions. The matrix form of organizational hierarchy *aims* to facilitate fluidity and continuity of knowledge-production, money, and people, but whether it can be effective in *achieving*

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[73] In recent years a countertrend of skepticism toward science and scientists has become especially prominent. Witness the largely conservative media reports that cast doubt on climate change, the religious groups who contest evolution, and the families who refuse to have their children vaccinated. Science and scientists have not converted all non-believers, a phenomenon addressed in this chapter's concluding remarks.

such an outcome is unclear. For instance, matrix forms of organization have received criticism for complicated reporting relationships, resource competition, and lack of long-term sustainability (e.g., Sá, 2008). Relatedly, social network analyses may help us understand the density and durability of connections among SOIs within an institution and in exchange relationships with external entities, as well as the nature of those exchanges.

Second, it may be helpful to *evaluate the effectiveness of SOIs in capturing federal R&D funding that might not otherwise be secured*. Do SOIs actually do what they aspire to? One approach to assessment may entail reviewing SOIs' annual reports, though such an analytic strategy requires a strong note of caution. Consider the Institute for Genomic Biology (IGB) at UIUC. Its 2014 print publication, "Where Science Meets Society," shows that the institute has received its very first grant funding of $8 million in 2004 ($3 million from Department of Energy and $5 million from National Science Foundation) and has reached, in 2013, $37 million in total external funding captured over its history (from mission agencies, industry partners, philanthropic foundations, etc.). On paper it seems that IGB has received the full amounts of these awards, when the institute may have only taken percentages of the grants won by affiliate faculty members.[74] What

[74] The $5 million NSF grant in 2004 provides an example. As the NSF award database shows, the grant entitled "BeeSpace – An Interactive Environment for Analyzing Nature and Nurture in Societal Roles" was given to a team of faculty members affiliated with IGB rather than to IGB itself (e.g., as a center-level grant). Indeed, awards of this size and scale may also be paid-out over time, which may make success-claims reported in any given year appear somewhat inflated. Another caveat in evaluation of SOIs includes faculty recruitment from one institution to another. For instance, as documentary primers collected on site suggest, nanoSTAR at UVa has recruited a top scientist who brings NIH funding that the faculty member won while at another university. The SOI now receives a portion of the external grant, a success-claim it shares publicly, but has not necessarily helped (and certainly has not *caused*) the faculty member to secure these resources.

is more, it remains unclear if IGB has helped UIUC capture grant funding that it might not have without IGB. Moving forward, assessment in this arena seems to require data adjusted for the proportion of awards that SOIs receive, payout of the awards over time, grants that follow faculty members from one institution to another, and costs associated with applying for the grants. To understand if SOIs have *marginal positive impacts* on their home institutions' federal R&D funding, this line of work may call for the use of econometric techniques, such as difference-in-differences. Such an approach may help to estimate federal R&D funding levels on a campus before and after any given SOI or set of SOIs relative to baseline funding levels and also relative to comparison groups.

Third, *studies that disaggregate SOIs may be helpful.* In this thesis, UIUC has been the only sampled institution to feature interdisciplinary schools. Surprisingly, UF has comparable size, scope, and scale of academic programs as UIUC but has not developed new schools. As compared to centers and institutes, by far the most popular emerging organizational units in the study, academic departments are seldom developed. UVa, for instance, did not form any new academic departments between 2000 and 2014, while UIUC and SBU each had one and UF had two. Event history analyses could illuminate the organizational antecedents of adoption of SOIs in general and of specific unit types (centers, institutes, schools, and departments) in particular. What is more, the proportion of departments and schools to centers and institutes raises intriguing research questions about the very future of departments and schools. If centers and institutes are becoming the dominant units of SOIs and also take on educational programs and grant degrees, as has been the case at Pennsylvania State University and Duke University (Geiger & Sá, 2008), we may ask whether schools and departments are viable moving forward.[75] Along these lines, which types of SOIs survive or die and why may be of particular theoretical and practical interest. The relationship among centers, institutes, schools, and departments may also suggest a fruitful area for further research. For instance, centers and institutes may initially seem to subvert traditional academic department forms, but could, as they develop and grow, morph into department-like entities and serve as an intermediary step toward the formation of interdisciplinary schools. In this way, centers and institutes could be the origin units in what eventually become department-like forms.

Fourth, *case studies of SOIs at research universities with inconsistent metrics in the quadrants of innovation developed in this thesis may deepen understandings of how context shapes organizational adaptation*. We do not know much about these institutions or their recourses to structural change. In this thesis, two institutions in particular offer examples of those that do not quite fit cleanly into quadrants based on institutionalization and resource position. Michigan State University (MSU) has been a member of the AAU since 1964, joining around the middle years of the field. It has a median federal R&D per FTE enrollment of $3,252, placing MSU below the public AAU average by about $2,300 or 40%, yet its median percent change in federally funded science of 11% exceeds the public AAU average by two percent. The University of California at Los Angeles

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[75] Hearn (2007) notes that matrix forms of organization in entrepreneurial research universities may lead toward this line of future research. As he writes, “In the entrepreneurial university, for example, matrix forms of organization may become more prevalent, with teaching organized programmatically rather than by departments, and with faculty assigned to more than one program. In such a scenario, the viability of the departmental form becomes uncertain. Which departmental functions would remain? As Gumport has put it, ‘What would a department be for?’ Identifying such prospective organizational ambiguities, and pursuing research to address them, merits analytic attention” (p. 255). For an early discussion of departments as viable organizational forms for the future, see Peterson (1976).

(UCLA) has been a member of the AAU since 1974, and while it has a median federal R&D per FTE enrollment of $11,000 (almost twice the amount of the public AAU average), its median percent change is 6% but lower than the public AAU average of 9%. MSU and UCLA fall between groupings of high or low institutionalization and resource strength or threat. Their contexts for innovation are intriguing and warrant empirical attention.

Fifth, *elite private institutions have long been the focus of research in this arena, but their inclusion in future work that looks at quadrants of innovation will be important.* Recall from Chapter 4 that in relation to the current group of public AAUs, the private AAUs have deeper status/standing in the field, higher federal R&D funding levels, and lower—by 1 percent—growth in federal R&D over time. They are considered not only more prestigious and wealthy, but also more nimble, creative, and fast-paced in their change and adaptation (Brint, 2005, 2007). Yet comparative work of SOIs within elite private institutions by quadrants of innovation may help us differentiate (1) influences of institutionalization and resource position on innovation from (2) influences of institutional control. It may also illuminate the extent to which private AAUs pursue organizational innovations in altogether new, novel arenas (e.g., Slaughter, 2014).

Sixth, *studies of administrative stratification in research universities seem warranted.* This thesis suggests the ascendancy of *scientists as administrators*, who gain disproportionate access to positions of organizational and financial authority. If this is indeed the case, researchers and analysts may ask, then, which faculty members are losing such opportunities in their roles and careers and in advancement to institutional leadership/stewardship?[76] While SOIs are essentially new organizational units, overlaying existing academic structures, they concentrate in and favor faculty members in STEM fields and disciplines. Yet there seems to be a gender gap within STEM fields and disciplines, as, in this thesis, male faculty members constitute the highest proportion (88%) of SOI administrators. Interestingly, though, women represent almost half (48%) of campus-level leadership in this study. Thus administrative stratification may have rather uneven effects within and across fields and disciplines. Indeed, whether faculty members in the humanities, social sciences, and fine and performing arts receive—or feature—comparable opportunities and patterns is unclear and worthy of future investigation.

Finally, *studies of the federal research policy system will continue to have importance.* As this thesis suggests, the federal R&D system of mission agencies may prompt innovation in organizational forms among research universities, but does it lead to innovation in knowledge production and advancements in science? Currently, fluidity and continuity of funding has become increasingly difficult to obtain. The way in which funding is allocated, budgets are shifted, and priorities are changed ad-hoc likely has adverse effects on scientists and their research.[77] Empirical investigations, as part of the research policy literature, may be helpful in developing further understandings of effects of federal R&D funding/mission agencies on scientific progress and innovation.

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[76] Likewise, we may ask: if star scientists become administrative leaders of the new generation of SOIs, which faculty members are left to lead the SOIs of the past?

[77] Stephan (2012) suggests that such challenges in the funding environment may make scientists more risk-averse in their work. For instance, researchers might focus on rather conservative but still somewhat fundable work instead of potentially groundbreaking, innovative projects with low probabilities of fundability and scientific success. Thus the likelihood of scientific advancement may be diminishing.

Relatedly, international comparative work in this arena may be especially helpful. For instance, Japan, Germany, and the Netherlands have each typically relied on research institutes independent of colleges and universities for scientific advancement (e.g., Dill & Van Vught, 2010). Whether the *structural location* of national innovation matters—and if so, to what extent—may shed some light on the sustainability of the U.S. system that prominently leverages organizational forms within higher education.

Concluding remarks

Researchers, analysts, and institutional leaders have long wondered about future forms of academic structure. Many of the dynamics and issues captured in this thesis are consistent with much of the prior literature and theory. But the findings of this thesis may bring about some informed conjectures about what may come next in organizational change and adaptation in research universities.

Without doubt, as this thesis suggests, we have heightened our reliance on and support of STEM. After all, scientific discoveries have helped us extend our life spans and expand the economy (Berman, 2012). As Stephan (2012) observes, "The U.S. love affair with funding for the life sciences—especially the biomedical sciences—is not difficult to understand. It is far easier for Congress to support research that the public perceives as benefiting their well-being" (p. 128). Such a "love affair" seems likely to intensify if not also become obsessive. The way in which research universities position around scientific funding, aiming to demonstrate their relevance and fundability in this arena, may actively perpetuate—and heighten—the wide-spread reverence for science and scientists.

Yet a countertrend has emerged, suggesting a possible *decline* in the reverence for science and scientists. A number of conservative-media pundits cast doubt on evidence of climate change, some religious groups vociferously deny evolution, and many families across the U.S. are refusing to have their children vaccinated. Paradoxically, in each of these cases, discourse suggests the use of "science" against science. At heart is the matter of which expert/specialist to trust and which body of evidence to follow. There will always be external threats to the professions (e.g., medicine, law, science, etc.), and it seems unlikely that even the most boisterous deniers of academic science will prevail. When we follow the money, tracking where the government spends tax dollars, the ascendancy of science is clear. Its ability to attract resources over time tells us that it is and will continue to be valued.

In the political economy, science may further solidify its hegemony amid the defunding of other fields and disciplines. For example, the University of North Carolina Board of Governors recently closed research centers that had focused on poverty, social change, and civic engagement (Jaschik, 2015). At the federal level, President Barack Obama has issued an executive order for governmental agencies to harness the behavioral sciences to serve the American people (White House, 2015). But whether R&D funding levels, within a tight budget and a rather stable hierarchy of priorities and outlays over time, will actually match this latest rhetoric remains to be seen. Overseas, national universities in Japan are moving to scale back on—and even eliminate—programs in the social sciences and humanities; such a development comes on the heels of the ministry's decree for higher education to adapt to society's needs (Grove, 2015). These latest developments seem to resonate with empirical literature that points toward widening stratification in academia: the STEM arena gains governmental and institutional resources that strengthen its positioning/prominence but at the expense and active *decline* of others.

Coincidentally, the strengthening "love affair" with science comes at a time of heightening importance of the *organization* as a social form. Despite some mistrust of public and private organizations alike over ethical concerns and scandals, we are in an era when legally an organization is considered a person.[78] Within such a context, this thesis suggests, bureaucracy and science are rising and also converging. Their cross-institutionalization seems likely to deepen and carries implications for the future of research universities and science more generally.

To elaborate, within research universities the academic unit is increasingly the established way of organizing and the scientist, rather than the administrative expert per se, is gaining access to organizational authority and money. In this way research universities may be simultaneously *responsive* to and also *facilitative* of the prominence of science in society. Schofer (1999) refers to such a phenomenon as "scientization:" the extent to which the domains of social life, domestically and abroad, come under the authority of science. Accordingly, science has been ascendant and institutionalized. Within this space, research universities are not entirely constrained in their organizational possibilities; they innovate, as SOIs suggest, contributing to this institutionalization and concretizing their social and economic functions.[79]

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[78] See Totenberg (2014) for a review of U.S. Supreme Court decisions that, over time, have granted rights to companies typically reserved for people.

[79] Scientization, as Schofer and Meyer (2005) elaborate, "increases the apparent utility of higher education for a wide range of social roles. This represents a sharp departure from

But are research universities—and their SOIs—necessary for advancing scientization and scientific progress? As noted in this chapter, not all countries rely on higher education to produce research for national innovation (Dill & Van Vught, 2010). Japan has traditionally utilized organizations outside of colleges and universities to contribute to knowledge production and the economy. Not until recently has it begun to strengthen the status of and funding for graduate education and the sciences in particular: a precursor to expanding the STEM research function of higher education institutions. Historically, Germany and the Netherlands have each leveraged research institutes independent of colleges and universities for economic competitiveness. And recently emerging private research institutes in the U.S. suggest developments analogous to longstanding approaches abroad.

Indeed, there is a small yet growing contingent of independent institutes in the U.S. The Howard Hughes Medical Institute opened the Janelia Farm Research Center in Ashburn, Virginia in 2006 to host and fund 250 resident researchers who study neural circuits and imaging. The Lieber Institute for Brain Development in Baltimore and the Institute for Systems Biology in Seattle are additional examples of organizations beyond higher education that work on scientific problems of national importance (Stephan, 2012). While these independent research institutes suggest structural alternatives for housing research, some—both in the U.S. and abroad—actively work with and ultimately become folded into universities. That SOIs *within* research universities have boundary-spanning capabilities, networking with external organizations, may especially help them to affirm their own and higher education's centrality in the advancement of knowledge.

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an earlier era where words such as 'academic' and 'scholastic' connoted a lack of relevance to practical matters" (p. 903).

SOIs, though certainly not the only mechanisms in the future directions of research universities, embody what makes higher education a unique, distinctly recognizable sector. Analogous to their home institutions, they derive legitimacy from specialization and expert knowledge. The proliferation—the production—of "specialists" rather than "generalists" has been an increasingly prominent function of higher education in the industrial era (Weber, 1958; see also Brint, 2005). In contemporary, postindustrial contexts of academic capitalism, SOIs in research universities may demonstrate their no longer latent purpose: to elevate the image of the ideal educated self as neither "generalist" nor "specialist" but as "scientist."

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APPENDIX A

CONTACT LETTER TO RESEARCH PARTICIPANTS

Date

Dr. ___________________
____

____

____
____

Dear Professor ________:

For a research project on new, innovative organizational forms in research universities, I am writing to ask whether you would be willing to participate in an interview with me on your campus the week of ________ or by phone later this month.

I am a PhD candidate in the Institute of Higher Education at the University of Georgia, under the guidance of Dr. Jim Hearn (jhearn@uga.edu), professor in our program. With this letter, I invite your participation in *Structuring to Advance Science*, a study of emerging centers, institutes, schools, and departments and cutting-edge STEM fields.

To expand knowledge of organizational change, my study design calls for interviews with people affiliated with innovative centers, institutes, schools, and departments. The study presents an opportunity for you to share general perspectives based on your experiences of how new organizational forms develop on campus and what they mean for science.

Your participation would entail an interview with me in your office, or by phone, for about 30 minutes. The interview comprises general questions about the work of the <center, institute, school, or department>, the formation and development of the <center, institute, school, or department>, and what the <center, institute, school, or department> means for advancing science. Unless otherwise preferred, our interview would be audio-recorded and deleted after verbatim transcription. You may also provide documents, such as reports and historical records, have me observe and take notes at a department meeting, and/or recommend additional participants.

Strong precautions will be taken to protect your identity. Only I will access your information, and a code linking you to your transcript, and the transcript itself, will be encrypted and stored in a password-protected computer in my locked home office. In papers from the study, quotations from or references to your interview will be attributed to a pseudonym or generic title ("a faculty member," "a scientist," etc.).

Your involvement is voluntary: you may decline or stop participation any time without penalty. If you withdraw, your materials will be included in the research unless requested otherwise in writing. I do hope you will participate, for your contributions to science and experiences as <administrator, faculty member, etc.> will make for truly rich insights and a successful study.

There are no known risks or discomforts associated with participating in the research. If you have any questions, you may contact me at jwarshaw@uga.edu. Questions about your rights as a study participant may be directed to: The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu.

Thank you. Please know how much I appreciate your help. I will call within the next week to invite your participation and address any questions that you may have about the study. I am very grateful for your time—and hope to have the chance to meet together.

All best wishes,

Jarrett B. Warshaw

APPENDIX B

INTERVIEW PROTOCOL

Part I: Spoken Introduction to Participants

This study examines organizational change in universities and its relationship to advancing science. Your institution and <center, institute, school, department> is one of several included in the study. You have the opportunity, in this interview, to share your perspectives of the work of the <center, institute, school, department>, the formation and development of the <center, institute, school, department>, and what the <center, institute, school, department> means for advancing science and the research core of your institution. The interview should take about 30 minutes. I would like to audio-record our interview today for accuracy in the research, with the recording deleted after verbatim transcription. May I audio-record the interview? Confidentiality is important to the integrity and success of the study, and I will take reasonable precautions to protect your identity. Any public release of findings from the study will not mention you or your name directly. Please let me know, at any point in the study, if you have questions about confidentiality. May we begin?

Part II: Guiding Questions

A. Aim, structure, and work

1. In your experience of the <institute, center, school, department>, what has been the primary aim of the organization(s)?

2. How does the structure of the <institute, center, school, or department> relate to the organization's aim?

3. To what extent does the structure of the organization influence the type of the work that can be done here?

4. In a typical day at the <center, institute, school, department>, what type of work is being done?
   Probe: What is it about the organization that facilitates pursuit of these projects?

5. What are the goals being fulfilled by the work of the <center, institute, school, department>?

6. What are the rewards or incentives being pursued here?

Probe: Which rewards or incentives—and from whom—seem most pressing or urgent in influencing the work of the <center, institute, school, department>?

B. Formation and development

7. How did the <center, institute, school, department> form?

8. To what extent does the development of the <center, institute, school, department> relate to other changes at the university?

9. How does the <center, institute, school, department> aim to form partnerships with other departments and faculty members on campus?

10. How does the <center, institute, school, department> relate to the mission and/or strategic plan of the university?
    Probe: What are the ways in which the <center, institute, school, department> self-advocates?

11. What are the resource challenges and/or opportunities that the <center, institute, school, department> encounters?
    Probe: Which strategies are being pursued in light of these conditions?

12. How do external funding conditions influence the <center, institute, school, department>?

13. How do peer or competing organizations at other universities influence the <center, institute, school, department>?
    Probe: How does the <center, institute, school, department> learn about other organizations?

14. In what ways does the structure of the organization influence how the <center, institute, school, department> interacts with external constituents (e.g., government, industry, etc.)?

C. Contributions to science

15. What have been the key advancements to science made by the <center, institute, school, department>?
    Probe: Could these advancements have been made by way of another organizational form on campus? Why or why not?

16. What are the distinct opportunities that the <center, institute, school, department> has in terms of its work?

17. What are the challenges that could limit the <center, institute, school, department> in its work?

18. What does it take, as an organization, to increase the chances of scientific advancement?

19. In what ways does the organization—in structure, work, and rewards/incentives—reflect conditions conducive to advancing science?

D. Preparation for the future

20. How does the <center, institute, school, department> prepare for its future?

21. In what ways does the <center, institute, school, department> continue to change?

22. As the <center, institute, school, department> learns about other programs on campus and at other universities, in what ways is that information acted upon as part of efforts to change?

23. Who or what will most strongly direct the future of the work of scientists at the <center, institute, school, department>
    Probe: Why?

Finally, one remaining question:

24. How will you define and measure the success of the <center, institute, school, department> moving forward?
    Probe: Why this definition and/or set of metrics?
    Probe: To what extent does seeking to meet these interests influence or perhaps compromise the science produced here?
    Probe: In what ways might success in this way influence the support and resources necessary for advancing science?

APPENDIX C

LIST OF CODES FOR DATA ANALYSIS

Within-case codes

Federal R&D funding—historical pattern of sponsorship for an institution

Federal R&D funding—recent trends/fluctuations in last five to 10 years

Federal R&D funding—longstanding scientific niches for an institution

Federal R&D funding—emerging scientific niches for an institution

Federal R&D funding—how bold, distinctive is organizational positioning for money?

Federal R&D funding—mission agencies most central in funding campus research

SOIs—normative/value claims as organizational entities that should endure

SOIs—financial/monetary claims as organizational entities financed to endure

SOIs—resemblance of matrix-like arrangements

SOIs—scientific directions toward which they lead their institutions

SOIs—degree of variation in type (center, institute, school, department) & structure (virtual or capital-intensive)

SOIs—business model of self-sustaining on federal R&D funding

SOIs—business model of leveraging state funding to pursue other monies

SOIs—business model of leveraging institutional funding to pursue other monies

SOIs—business model of leveraging philanthropic gifts to endow unit/faculty

SOIs—business model of leveraging industry money to fund research/core technology

SOIs—business model of seed-funding other units on campus

University context—strategic planning that overlays/informs development of SOIs

University context—historical, normative climate of what's valued/legitimate

University context—historical financial priorities/commitments

University context—aspirations/ambitions for status/standing in the AAU

University context—disconnect between aspirations/ambitions and financial resources

University context—faculty heroes and legends (e.g., Nobel laureates)

University context—state governance and finance in relation to campus innovation

University context—state system of higher ed influence on campus innovation

Cross-case codes

Nature of variation

"Life of its own"—goal displacement for survival

"Life of its own"—politicized/competes for normative legitimacy on campus

"Life of its own"—politicized/competes for financial resources on campus

"Life of its own"—adaptive, short-term "solutions" to knowledge production/resources

"Life of its own"—adaptive, but turning into longstanding units

"Life of its own"—may or may not increase research funding (e.g., proven or unproven?)

"Life of its own"—environment &/or institution controls SOIs, exerts power over them

"Life of its own"—SOIs exert control, power on campus

Medical access—crossover of faculty/personnel among academic and medical schools

Medical access—we're positioning for more NIH money and/or clinical trials

Medical access—is medical profession weakening academic core?

Medical access—is medical profession strengthening academic core?

Medical access—is medical profession subsuming academic core?

Medical access—normative/value and financial benefits for SOIs

Medical access—convergence across cases in scientific niches/directions

Medical access—distinctiveness across cases in scientific niches/directions

Medical access—this SOI has nothing to do with medicine or life sciences

External influences

Funding streams—responsiveness to what mission agencies fund/funding levels

Funding streams—responsiveness to hot topics (e.g., anthrax, genomics, big data, etc.)

Funding streams—involvement of scientific community in outlays/allocation decisions

Funding streams—SOIs are platforms for strengthening scientific credentials/credibility

Funding streams—SOIs are platforms for "manipulating" fed funding priorities/outlays

Funding streams—SOIs lead mission agencies toward new funding areas (we produce strong science, mission agencies follow us)

Status/standing—claims of expertise/specialization for academic relevance

Status/standing—claims of expertise/specialization for economic/financial relevance

Status/standing—relationship of academic structure and status/standing in AAU

Status/standing—examples of resistance toward AAU

Status/standing—examples of acquiescence to normative cues from AAU

Status/standing—examples of influencing how the AAU self-regulates membership

Campus influences

Administrator-faculty boundaries—campus administrators forming/running SOIs

Administrator-faculty boundaries—faculty forming/running SOIs

Administrator-faculty boundaries—faculty becoming administrators for research benefits

Administrator-faculty boundaries—faculty leaving administration for research benefits

Administrator-faculty boundaries—faculty as administrators to form new disciplines

Administrator-faculty boundaries—"authentic academics" (experts) leading org change

Administrator-faculty boundaries—types of expertise/specialization (e.g., scientific/professional, managerial, etc.) to enter administration/financial stewardship

Ascendancy of academic capitalism—SOIs are subsidized to compete for external money

Ascendancy of academic capitalism—SOIs are subsidized to profit in markets

Ascendancy of academic capitalism—SOIs need industry money for research continuity

Ascendancy of academic capitalism—SOIs are buffering from market/industry interests

Ascendancy of academic capitalism—SOIs create new networks among industry partners

Ascendancy of academic capitalism—SOIs utilize industry for "cutting-edge" science

Ascendancy of academic capitalism—SOIs draw on other money to resist industry

Ascendancy of academic capitalism—SOIs embrace mix of market, academic rewards

Ascendancy of academic capitalism—SOIs facilitate/reproduce academic capitalism

Ascendancy of academic capitalism—SOIs uphold/protect campus values/interests